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PERSONALITY DIFFERENCES AND PERFORMANCE ON THE CONTINUOUS PERFORMANCE TEST

by

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ABSTRACT

PERSONALITY DIFFERENCES IN PERFORMANCE ON THE CONTINUOUS PERFORMANCE TEST

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Eysenck has applied Pavlov's typological postulate to a number of experimental situations including perceptual motor performance. For example, he has applied his version of the Hull-Kimble theory of inhibition to pursuit rotor performance and reminiscence phenomena. In its most recent formulation, this theory has encompassed three main concepts; inhibition, consolidation, and reminiscence. The relationship between these three concepts is of a task specific nature; that is, different perceptual-motor tasks involve different degrees of inhibition and of consolidation in the production of reminiscence effects. In some tasks reminiscence is due to the consolidation of learning; whereas, in other tasks there is little learning to be consolidated and reminiscence is due to the dissipation of inhibition.

A rather considerable interest in the application of these concepts in an attempt to link personality differences with individual differences in perceptual-motor performance has existed for some time, but there has been relatively little research attempting an analysis of performance decrement per se. In fact, the design trend in most studies linking E-I with task performance has been to attenuate inhibition effects because they confound experimental measures of consolidation and reminiscence.

In the present study an attempt has been made to analyze

performance decrement during the performance of a short signal vigilance task using a modified version of Rosvold's Continuous Performance Test apparatus. The results demonstrate a highly significant relationship between performance decrement measured in terms of response latency, failure to respond to the critical stimulus and incorrect response; and the personality dimension E-I. Performance decrement by these measures was greatest in the extravert group and least in the introvert group. The results of this study lend strong support to the relationships regarding inhibition postulated by Eysenck's theory.

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INTRODUCTION

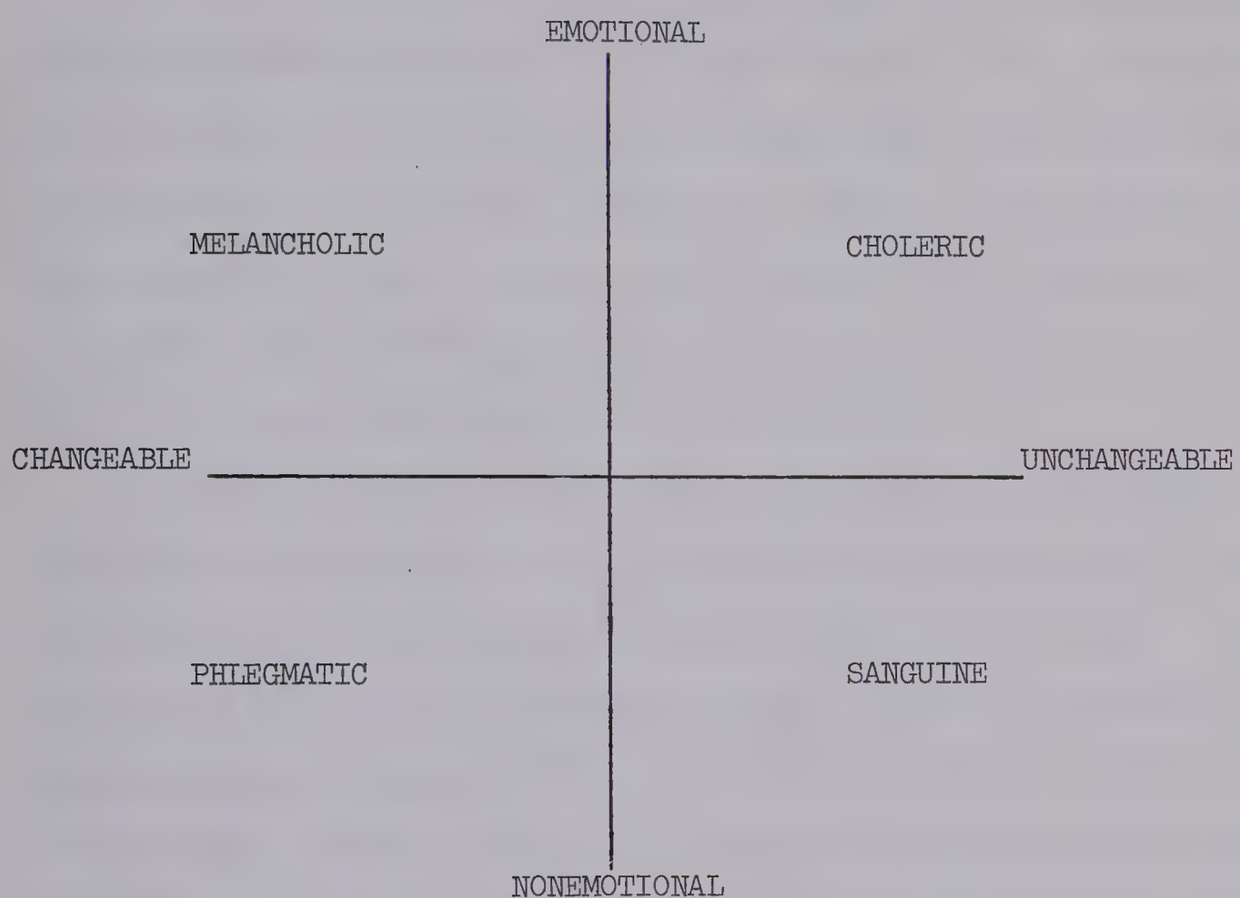
INTRODUCTION

Theories of personality based on a classification of types have frequently appeared in psychology. Such theories are of interest to psychologists, for the concept of personality type has had a long and important role in the history of psychology, and is a still viable issue in present day psychology.

Historically speaking, the oldest known categories of personality types originated with the ancient Greeks' theory of the four humors. This theory was central to the life philosophies of the great physician-philosopher Hippocrates who conceived of the human body as being made up of four elements: air, water, fire, and earth. A later and equally famous Greek physician, Galen, developed a classification of temperaments based on the theory of humors. Galen distinguished four fundamental temperaments: the choleric, the melancholic, the phlegmatic, and the sanguine. It was his idea that a predominance of any one of these elements would produce a certain temperament. Galen's schema played an important role in the work of the German philosopher Kant and later had considerable influence on the psychologist Wundt. According to the Galen-Kant-Wundt theory personality description, there are four fixed and separate temperaments, each classified according to emotional type and the relative amount of change in behavior of the individual. A schematic diagram of this system is given in Figure In-1 (Eysenck, 1967).

While the still common usage of Galen's temperaments as descriptive categories of human behavior testifies to their impact on Western thought, from the standpoint of psychological theory their

FIGURE In-1



THE GALEN-KANT-WUNDT SYSTEM OF FOUR TEMPERAMENTS

naivete has long been apparent (Jung, 1928). References to descriptive theories of personality based on "personality type" are to be found in the works of many early researchers, among them Jordon, who may be considered as one of the first modern type theorists. In his work Character as seen in Body and Parentage (1896), he proposes a type theory based on a continuum, the polar points of which are action and reflection.

The American psychologist William James (1907) introduced the concept of "tough-minded" and "tender-minded" types. James' description is of special interest because recent work by Cattell (1957, 1965) confirms the presence of a factor ("Premsia vs. Harria") quite similar to those described by James. In this case, typical of many, the purely descriptive work of an early researcher has been reconfirmed by the later and far more sophisticated methods of modern science.

Another such descriptive type is the concept of extraversion-introversion, which is one of the very few personality constructs to have remained controversial and productive of research over the years. The actual terms extraversion-introversion form an important historical concept, appearing frequently for over two hundred years in common European usage (Eysenck, 1965). In a recent, comprehensive review, Browne (1969) attempted to trace the origin of the terms extraversion and introversion and found that perhaps the first usage of the term extraversion in a behavioral sense was that of Coles (1692 - 1732) who defined extraversion as a turning of one's thoughts upon outward objects.

The modern use of these terms begins with the German psychologist Stern (1900) who introduced the concept of "subjective and objective types" in the first year of the present century. His work received relatively little attention and it was not until Jung (1923) developed a descriptive

framework which combined Stern's ideas of subjectivity-objectivity with the older concept of introversion-extraversion that the terms attracted wide attention in psychology and related disciplines. Therefore, even though Jung has frequently been cited as the originator of the terms "introversion" and "extraversion", it would be more appropriate to say that Jung first popularized these terms, gave a full definition of them, and made use of them in a theory of personality based on individual classification by type.

Jung (1923) defined type as a "characteristic model of a general attitude occurring in many individual forms . . . in so far as such an attitude is habitual . . . I speak of psychological type . . . should the state of extraversion become habitual, the extraverted type appears," (Ibid., p. 543). Jung further describes extraversion-introversion as a "dimension" of personality. He describes extraversion as an "outward turning of the libido . . . an outgoing transference of interest from subject to object." (p. 543) In similar manner introversion is described as a "turning inwards of the libido whereby a negative relation of subject to object is expressed." (p. 567)

Further elaborating on his position, we note Jung's view that:

> "every individual possesses both the mechanism of introversion and that of extraversion, and it is only the relative strength of one as compared with the other which creates the type ... If this dominance should for whatever reason become chronic, then we would be faced with a type, ie. the habitual dominance of one mechanism..... Type never denotes more than the relative dominance of one mechanism." (p. 10)

As can readily be seen Jung did not conceive of all individuals as being introverted or extraverted. Rather, most individuals may be placed in some balanced position on a continuum between two extremes, and a very small number of individuals may be conceptualized as occupying an extreme position because of a marked dominance of one characteristic over the other. Thus, Jung stresses the notion of complete continuity and balance. While he speaks of "ideal" types, he repeatedly stresses that the concept of the completely extraverted or completely introverted individual is a matter of degree.

Recapitulating his position in a later paper, Jung (1928) stresses:

> "Strictly speaking, there are in reality no unqualified extraverts or introverts, but extraverted and introverted function-types, such as thinking types, sensation types, etc.... For the sake of completeness, I must also observe that the classification of types according to extraversion and introversion is by no means to be regarded as the only possible method. Any other psychological criterion would be equally well employed, although, in my view, no other possesses so great a practical significance." (p. 312)

Following Jung, several researchers made use of the idea of psychological type, among them were: Kretschmer (1950) who, on a basis of clinical observation, described the personality dimension cycloid vs. schizophrenic; Wittenborn et. al. (1951) and their description of non-euphoric mania; and Maslow (1937) who described a pattern of behavior which can be characterized as dominance vs. submission.

Theories involving typology have been subjected to much criticism, generally on historical grounds. An example of the most common criticism of type theory is to be found in Hilgard and Atkinson (1967) who warn the introductory psychology student of "two dangers" in type theories:

> "1. The type description tends to assert too much about the individual ...
>
> (and)
>
> 2. The type description tends to hold to outmoded conceptions of personality and especially neglects cultural influences." (p. 469)

The first criticism made by Hilgard and Atkinson is aimed at extensions of the old notion of dichotomy of type. This criticism is applicable to theories that "pigeon hole" behavior or that create a stereotype of the person according to such a "pigeon hole classification".

Perhaps the best rebuttal of this criticism comes from Eysenck (1961) who discusses the differences between the early psychiatric models based on the notion of fixed types and the more flexible "dimension" approach.

> "Continuity is thus substituted for discontinuity, and measurement for discrete classification. The large number of neurotics which on the existing scheme of classification turn out to combine features from several diagnostic categories or have to be lumped together as 'mixed' in their symptomatology, are accommodated as easily in the dimensional scheme as are the 'typical' but rare hysterics and dysthymics."

Modern type theory which speaks of type as a dimensional concept does not stereotype the individual; instead, it attempts measurement and description of the individual on the basis of objective characteristics.

The second criticism is simply not applicable to modern type-trait theory which lays great stress on the interaction of cultural influences and basic personality dimensions. The holistic approach of the modern factor analytic approach is stressed by the majority of workers in the field, among them Cattell (1963) who states:

> "The common basis in clinical and multivariate - especially factor analytic - approaches is far wider than either of these two specialties is apt to recognize. The clinician, in contrast to the old style brass instrument "experimentalist", has habitually looked at things holistically. He has been concerned with the whole person, and also with the totality of situational variables. Frequently he has literally been trying to perform factor analysis in his head. For example, when he developed the idea that something exists called the ego, and that a dynamic unity exists that may be called the super ego, or that certain particular defense mechanisms are operative, he has inferred these entities from observations of many things which co-vary. He has begun with patient observation, but of a multivariate kind, and then he has let his memory operate selectively upon the series of patients he has seen to ask what "goes together". In fact, he has done really just what the multivariate experimentalist is doing; but he has done it without recording measurements at the time, and above all without benefit of a fully thought out mathematical model and the help of an electronic computer." (pp. 418 - 419)

In summary, the classification of human behavior into different types has had a long and important role in the history of psychology. Despite the criticisms directed against type theories,

factor analytic research on personality types continues to direct an appreciable amount of research especially in the area of personality theory based on concepts of dimensionality (Stein, 1963).

The work of Hovey (1929), Bernreuter (1934), Guilford (1934), and other researchers of the thirties marks the beginning of what Cattell (1956) has called 'personality and motivation theory based on structural measurement'. The most important evidence bearing on personality structure has resulted from the work of the research groups founded by Guilford, Thurstone and Cattell in North America and Eysenck in the United Kingdom. This thesis will deal primarily with the work of Eysenck, because he in particular has developed a theoretical system which lends itself to experimental evaluation.

CHAPTER I

REVIEW OF THE LITERATURE

THE DEVELOPMENT OF EYSENCK'S THEORY

It is important to first state that the term theory, when applied to Eysenck's work, is perhaps a bit misleading in that Eysenck's work has contributed to a formal system of postulates, not a monolithic theory. Eysenck's theory is what Rozeboom (1965) terms a "propositional" theory or, "A set of propositions about the way the world is put together". The development of these postulates falls into three main phases: the first phase which may be called the "structural phase"; an intermediate phase which we identify with the development of Eysenck's "two-factor theory of reminiscence"; and the contemporary phase in which we have seen the development of Eysenck's present "three-factor theory of reminiscence".

The Structural Phase

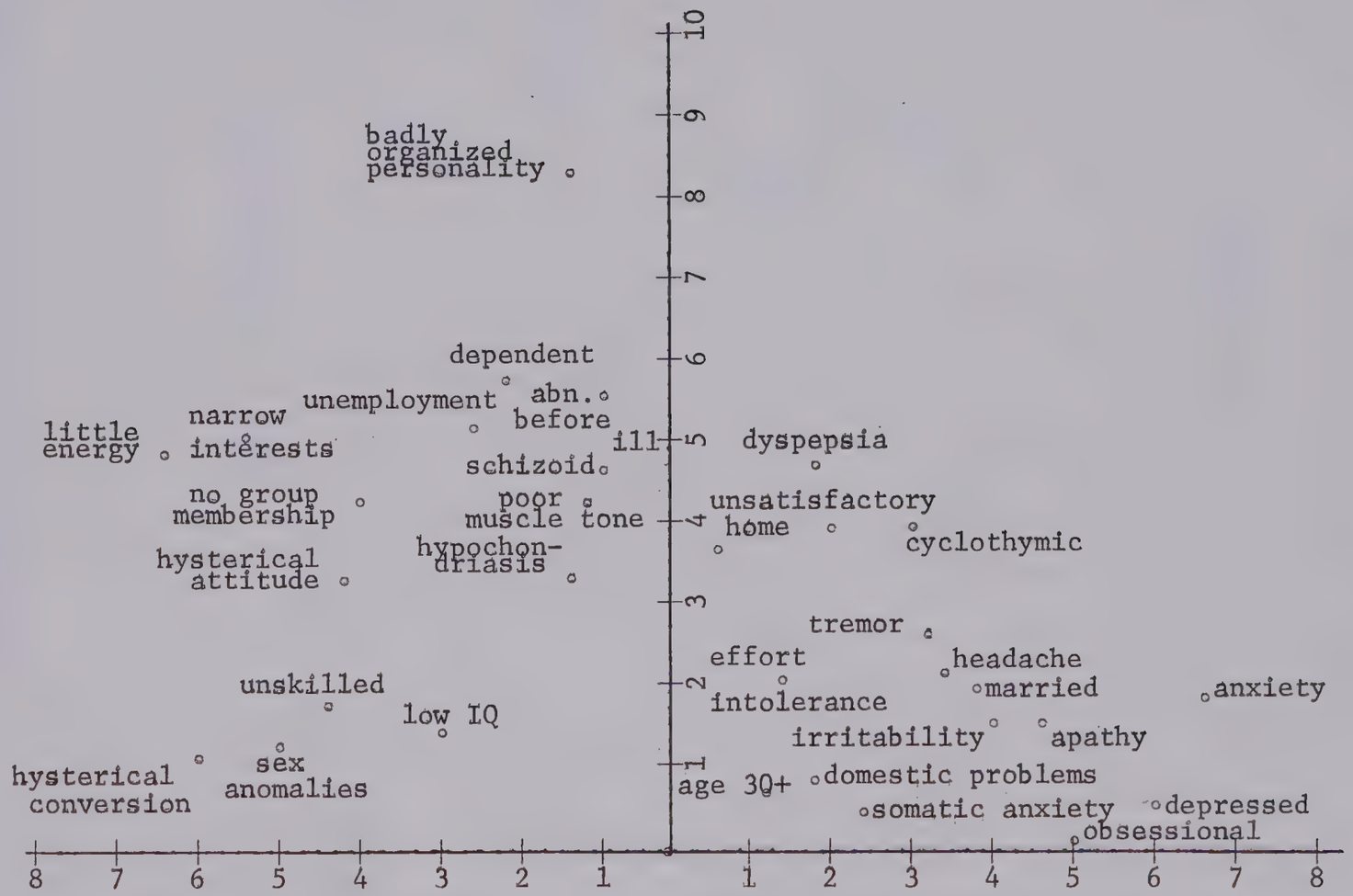
The first of these phases may be said to have been a period of structural investigation and operationalization. It was Eysenck's aim to provide an objective basis for linking personality traits with major structural dimensions of personality. At this time, there was no attempt to provide a theoretical basis or explanation for the experimental observations; instead, the main emphasis of the work was on the discovery, identification and characterization of major personality dimensions.

The first of a series of studies investigating the structural dimensions of human personality was begun by Eysenck (1947) using thirty-nine symptomatic and descriptive items which were inter-

correlated for seven hundred neurotic patients. The results of the study lend support to Janet's hypothesis concerning the sharp division between hysterical disorders and dysthymic disorders. These results are shown in Figure I-1.

The results show that abnormal subjects are distributed over a two-dimensional continuum or factor space. One dimension, the E-I dimension, is bi-polar and, according to Eysenck, a unitary factor. The other dimension, identified as the N or neuroticism factor is independent (orthogonal) of the E-I dimension and is also a unitary factor. However, with the identification of these personality dimensions, a large body of experimental evidence on the existence of performance differences correlated with personality dimensions began to accumulate. One of the most impressive studies is reported by Hildebrand (1953) who tested four groups of subjects divided on the basis of clinical diagnosis. A factor analysis carried out on the test results showed that all factor loadings were generally in accord with Eysenck's findings concerning the distribution of the various clinical groups along the two-dimensional framework proposed by Eysenck. In a similar series of experiments Hildebrand (1958) published a factor analytic study of the test performances of twenty-five conversion hysterics, twenty psychopaths, ten reactive depressives, ten obsessional neurotics, twenty-five anxiety states, fifty-five neurotics of mixed symptomatology, and a sample of normal subjects. Twenty-five tests in all were used for this study including questionnaires, performance tests and measures of intelligence. Three main factors emerged: neuroticism, extraversion, and intelligence. The distribution of the clusters of the experimental groups is given in Figure I-2.

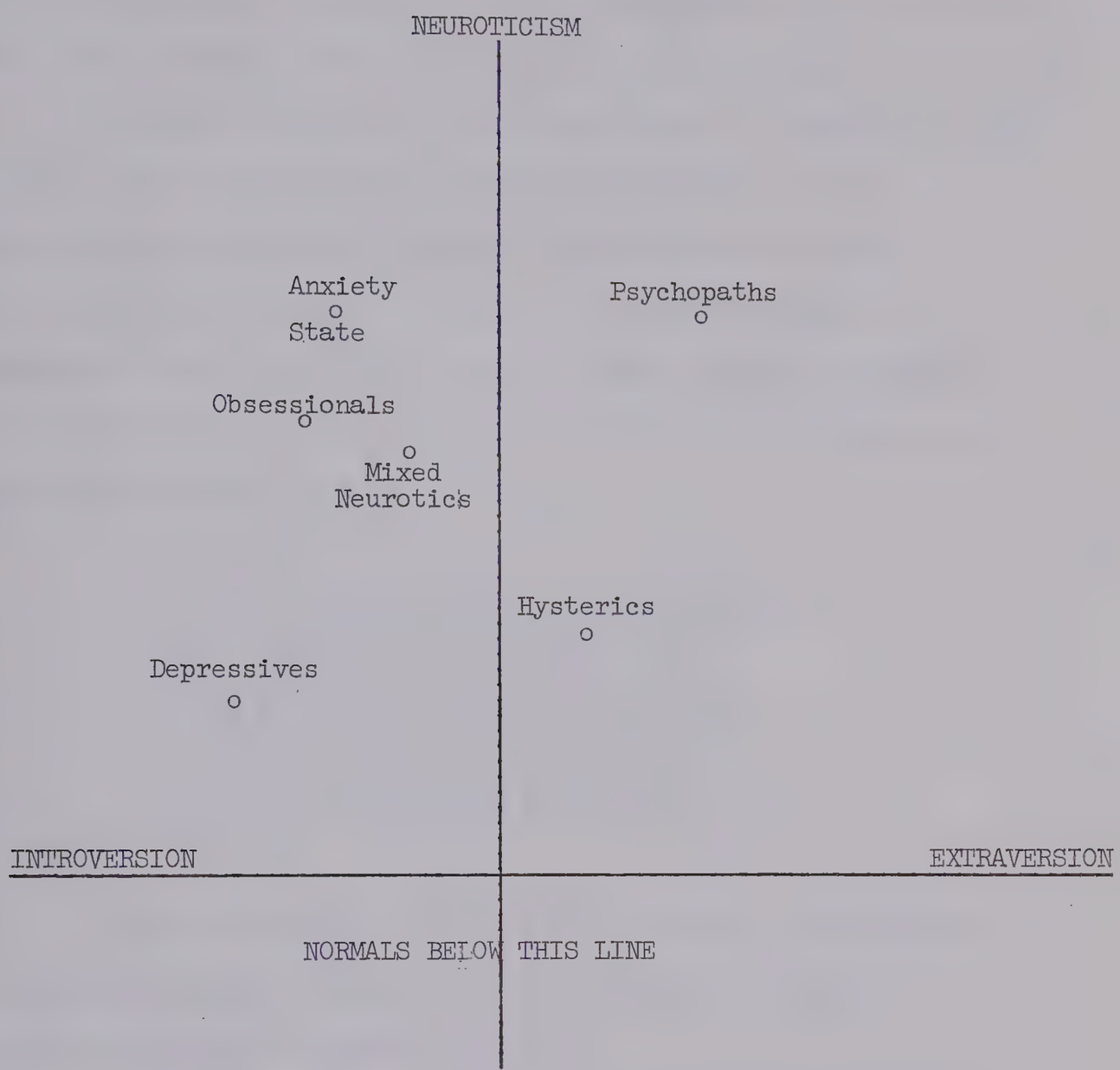
FIGURE I-1



ITEMS DEFINING NEUROTICISM AND EXTRAVERSION-INTROVERSION FACTORS

(Adapted From Eysenck, 1960)

FIGURE I-2



POSITION OF ONE NORMAL AND SIX NEUROTIC GROUPS

IN TWO DIMENSIONAL FRAMEWORK

(Adapted from Eysenck, 1957A, After Hildebrand, 1953)

Inspection of these results clearly indicates that the distribution of the experimental groups closely follows Eysenck's findings. The hysterics and psychopaths cluster at the extravert end of the distribution, the dysthymics at the introvert end of the distribution, with the mixed neurotics occupying a central position.

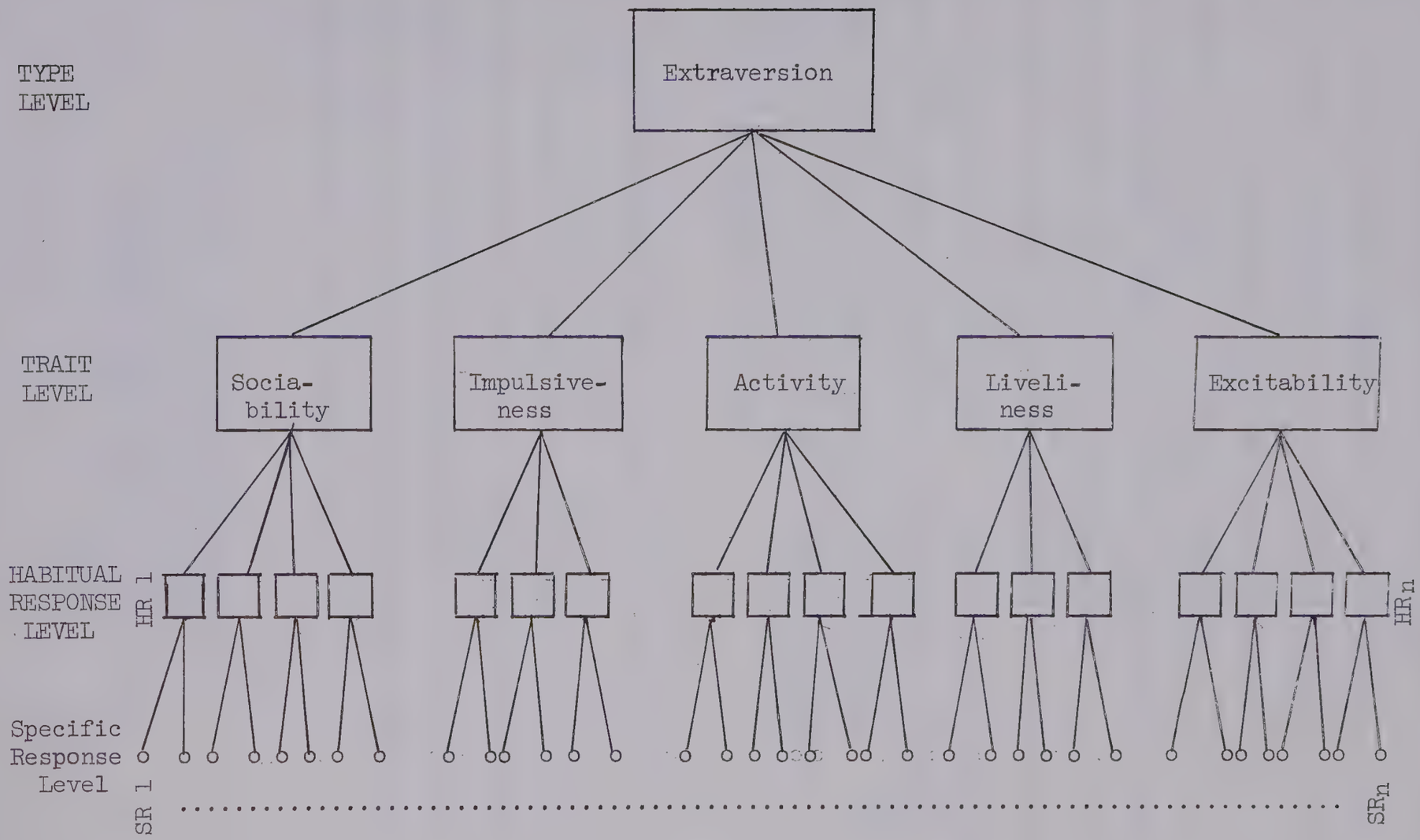
In these studies there is also an attempt to reconcile trait and type theory, Eysenck (1947) defining type as "an observed constellation or syndrome of traits". For example, introversion as a type is characterized as a collection of traits like rigidity, persistence, subjectivity and so forth. Further research by Eysenck (1953) resulted in the identification of other personality dimensions. Eysenck observed that:

> "...At the type level, i.e. at a level where concepts are based essentially on the intercorrelations between traits, three main dimensions appear to have been established: Neuroticism, Extraversion-introversion, and Psychoticism. These three dimensions appear to be relatively orthogonal to each other..." (p. 318)

This reconciliation can best be understood by referring to the following diagram (Figure I-3) which shows the hierarchical concept of personality (Eysenck, 1947).

This figure shows in some detail the conception of extraversion as a personality dimension based upon the intercorrelations between a number of different traits. The traits are themselves based upon patterns of habitual response which in turn are based upon quite numerous specific responses.

FIGURE I-3



HIERARCHICAL MODEL OF PERSONALITY (Adapted from Eysenck, 1947)

In a summary-review of early research studies using factor analytic methods, Eysenck (1953) observes that in the main, these studies agree on the existence of personality dimensions and that the application of factor analytic methods to the investigation of psychological types results in hypotheses which may be studied by means of reproduceable experiments. To this point, work had mainly been of a structural nature, that is the emphasis was on exploration rather than on theorizing. However, as experimental evidence accumulated, a theory was soon forthcoming. In 1955, Eysenck (1955) proposed a theory of extraversion-introversion which attempted to account for performance differences between the two personality groups. This theory may be conveniently referred to as Eysenck's two-factor theory of extraversion-introversion.

The Intermediate Phase: Eysenck's Two-Factor Theory

Eysenck (1955) postulated a theory largely derived from the work of Pavlov and of Hull which related the personality dimension Extraversion-Introversion (E-I) with perceptual-motor performance. As Hullian theory did not take into account individual differences, Eysenck proffered the following postulates:

1. "Human beings differ with respect to the speed with which reactive inhibition is produced, and the speed with which reactive inhibition is dissipated." (pp. 34-35)

2. "Individuals in whom reactive inhibition is generated quickly, on whom strong reactive inhibitions are generated, and in whom reactive inhibition is dissipated slowly are thereby predisposed to develop extraverted patterns of behavior ...; conversely, individuals in whom reactive inhibition has developed slowly, in whom weak reactive inhibitions are generated, and in whom reactive inhibition is dissipated quickly are thereby predisposed to develop introverted patterns of behavior." (p. 35)

In a later reformulation of his theory and a comprehensive review of the experimental evidence bearing on it, Eysenck (1957) has made one important change in his conceptualization. Hull had accepted the Mowrer-Miller 'work hypothesis' in which inhibition was considered to be a function of the actual physical work done by the organism. Numerous studies, among them Ellis, Montgomery, and Underwood (1952) and Bilodeau and Bilodeau (1954), have shown that inhibition effects are closely related to the amount of continued attention required by the task. Thus in encompassing learning in his theory, Eysenck seems to accept a central notion of inhibition rather than the older peripheral concept; a notion which is more in keeping with experimental results. Eysenck's two-factor theory may be briefly stated as follows:

1. Continuous or massed performance produces a negative drive state called reactive inhibition (I_r) which, as performance continues, grows until it equals drive (D), the drive which is maintaining the performance.

2. At the point where I_r=D occurs, there is no longer any D to maintain the performance, performance ceases, and an involuntary rest pause (IRP) occurs.

3. During this IRP, I_r dissipates so that I_r< D and performance is reinstituted.

4. Steps 1 through 3 are repeated and because of the alternating accumulation and spontaneous dissipation of I_r during an IRP, performance falls into a cyclical pattern.

If a programmed rest pause is inserted into the experimental procedure, I_r will be dissipated during the rest period. When performance is resumed a post-rest increase in performance occurs. This increase in performance caused by the spontaneous dissipation of I_r during rest is called reminiscence. An example of this effect is the well established post-rest upswing in pursuit rotor performance following a programmed rest after massed performance (White, 1968).

It should be noted that in conceiving of I_r as a negative drive and so formally equating satiation with I_r, Eysenck (1957B) has relinquished certain elements in the Hull-Kimble concept and reverted to earlier Pavlovian ones; principally, the adoption of a theoretical formulation stressing a central concept of I_r, rather than a peripheral one. In short, Eysenck clearly differentiates performance decrement caused by failure of some central process from simple physiological exhaustion in peripheral muscle areas. This central concept of I_r is quite similar to the criteria defining some types of fatigue proposed

by Fraser (1958) and based on his experimental work in the study of fatigue. Fraser provides the following description of fatigue processes:

> "In the first place, fatigue tends to affect high-grade performance long before there are signs of physiological exhaustion. The more complex the performance, the more delicate the discriminations, the greater the number of sources of information which have to be attended to, the more likely the performance is to suffer from fatigue. There is not necessarily a gross falling off in performance, or extensive errors, or long patches of bad work. Rather we find at first the occasional slip, the momentary confusion of two similar signals, the slight pause in the smooth rhythm of skilled performance. The significance of this depends on the nature of the performance... We ourselves are very concerned about these momentary lapses in attention and slight lengthening of reaction times, since the over-increasing speed of aircraft means that they assume an importance out of all proportion to their size."

The reader should note that Fraser's descriptive definition of the fatigue process is essentially the same as Eysenck's (1967) description of the effects of I_r. Both Fraser and Eysenck are discussing performance failure induced through a central process as differentiated from performance failure due to physiological exhaustion. Fraser provides an apt summary of the I_r-Fatigue question by suggesting, as does Eysenck, that performance decrement is not a unitary concept.

> "It is misleading to consider fatigue as a single and simple phenomenon which builds up in the same way under different conditions

> and in different individuals. Several types of fatigue can already be distinguished occurring under different conditions, in different types of activity, and requiring different methods of study and measurement. Individual differences in susceptibility to fatigue are also clearly evident."

An additional factor present in Eysenck's theoretical framework is conditioned inhibition ($_{s}I_{r}$) which can be considered a negative habit phenomenon. Because reactive inhibition is a negative drive state which is reduced during either an IRP or a programmed rest pause, the IRP or the programmed rest pause acquires reinforcing properties. The reinforcement acquired by these drive reduction mechanisms strengthens the prevailing state of affairs during rest which is the habit of not responding. This habit of not responding is conditioned inhibition. Conditioned inhibition combines with reactive inhibition to maintain the state of non-performance. Since conditioned inhibition is a habit, it does not spontaneously decay during rest; however, as we have noted, reactive inhibition does decay and when $D > I_{r}$, performance recommences. Resumption of performance extinguishes conditioned inhibition due to non-reinforcement.

The exact manner in which conditioned inhibition and reactive inhibition combine has been the subject of many investigations and reformulations. The reader is referred to the excellent reviews by Jones (1958) and Jensen (1961) for a detailed history of these reformulations.

Hull's formulation in all versions of his theory proposes that

conditioned inhibition and reactive inhibition are related additively in this manner (Hull, 1952):

$$s\bar{E}_r = (D \times {}_sH_r) - (I_r \times {}_sI_r)$$

Hilgard (1956) suggests that if reactive inhibition is a drive state it should react multiplicatively in the manner of drive and habit strength. He gives this formula:

$$s\bar{E}_r = ((D - I_r) \times {}_sH_r) - (I_r \times {}_sI_r)$$

Also, reformulating Hull's theory so that it is consistent with Hull's postulates which suggest that drives and habits are always multiplicatively related, Iwahara (1957) suggests the following formula:

$$s\bar{E}_r = {}_sH_r (D - ({}_sI_r \times I_r))$$

Jones (1958) incorporates Osgood's (1953) suggestion that conditioned inhibition is negative habit strength and so it would be logical to subtract it from habit strength. Jones' reformulation combines all of the essential properties of all the above reformulations into this expression:

$$s\bar{E}_r = ({}_sH_r - {}_sI_r) - (D - I_r)$$

This formulation has been extensively used by Eysenck (1957)

as the basis for his learning model.

An additional reformulation which conforms to Iwahara's suggestion that drives and habits are multiplicatively related has been suggested by Howarth (White, 1967), who proposes this formula:

$$_{s}\bar{E}_{r} = (_{s}H_{r} \times D) - (_{s}I_{r} \times I_{r})$$

This reformulation would best seem to describe the effect of conditioned inhibition given by Kendrick (1958) and the description of recent empirical findings given by Eysenck (1967).

However, it should be noted that all of these formulae are descriptive and are not by any means exact statements of learning processes. While it is true that no amount of reformulation will overcome the failure of Hull's theory when attempting exact quantification of the learning process, as a method of describing the processes involved in learning it is still a useful tool.

From this discussion, it would then seem that $_{s}I_{r}$ has two major effects in Eysenck's model:

1. $_{s}I_{r}$ would have an additive effect with I_{r} in opposing D; and,

2. the gradual dissipation of I_{r} from extinction following a rest period would contaminate the reminiscence effect as a measure of either I_{r} or D. The effect of this dissipation of $_{s}I_{r}$ will appear in performance as a marked and prolonged post-rest upswing in performance. That is, the initial post-rest performance

increase due to the decay of I_r will be moderated and extended by the gradual dissipation of $_sI_r$.

The confounding effects of $_sI_r$ on experimental results, especially those involving a reminiscence effect, are well-known. Eysenck (1962) establishes a number of general experimental parameters which are necessary to obtain optimum results with perceptual-motor tasks such as the pursuit rotor. Some of these factors are:

1. Length (massing) of pre-rest practice.
2. Measure of performance.
3. Length of the programmed rest pause.
4. Level of performance at which measures are taken.

The length of pre-rest practice is important because extraverts develop I_r more rapidly than do introverts; therefore an early rest pause would be more advantageous to extraverts. Yet, if there is a long pre-rest practice, IRPs may take place thus allowing the development of $_sI_r$, the extinction of which in the post-rest period may confound the measure of reminiscence. Also, the measure of performance must be carefully chosen so that it does not place one experimental group at a disadvantage as previously discussed. In addition, the rest pause must be long enough to allow accumulated I_r to decay. If the rest period is too short, then the extraverts who dissipate I_r more slowly than introverts will carry I_r over into the post-rest performance, causing a loss of performance due to the reduction of D by I_r. Likewise, it is important, in experiments involving reminiscence, that the level or amount of performance be taken near the beginning of the learning curve since in later stages ceiling effects and long previous

practice which has allowed much ${}_{s}I_{r}$ to accumulate may interfere with the measure of reminiscence.

Three major predictions (Eysenck, 1957B) may be made from the two-factor theory:

1. Introverts form conditioned reflexes more readily than extraverts and extinguish less readily than extraverts.

2. Extraverts show satiation effects more strongly, more readily and more lastingly than introverts.

3. Massed practice should be more detrimental for extraverts than for introverts, as compared with spaced practice, and reminiscence phenomena, as measures of the inhibition accumulated during massed practice should be more pronounced in extraverts than introverts.

The prediction derived from Eysenck's postulates concerning the establishment of conditioned responses has received much experimental attention. Franks (1956, 1957) obtained results which strongly support Eysenck's prediction that conditionability was closely related to extraversion-introversion. This study used eyeblink conditioning as a measure of conditionability, and as Storms and Sigal (1958) in a critique of Frank's experiments, point out:

> "The available evidence suggests that different conditioning measures either do not correlate or are related very slightly, ... and little generality among different measures of conditioning

> has been shown. It would seem therefore that Eysenck would have been well advised to speak of eyeblink acquisition rather than conditionability". (p. 234)

However other studies using different types of conditioning have obtained similar results. Gelfand and Winder (1961) in their study of operant conditioning of verbal behavior in dysthymics and hysterics essentially confirm the relationship between the rate of behavior acquisition and extraversion-introversion.

Several experiments designed to test the introversion-extraversion relationship and conditioning using eyeblink conditioning have been exhaustively reviewed by Franks (1963), and in general, these studies lend support to Eysenck's prediction. However, other researchers, among them Becker and Matteson (1961), using classical conditioning of the psycho-galvanic response, and Yates and Laszlo (1965) using the pursuit rotor as a perceptual-motor task have obtained results which are not in the direction predicted by Eysenck.

Norcross, Lipman, and Spitz, (1961), also found results that fail to confirm Eysenck's hypothesis that extraverts show satiation effects more readily and to a greater and longer lasting degree than introverts. Using visual and kinesthetic satiation effects, the researchers found only one correlation out of a total of twenty that was significant in the direction predicted by Eysenck. Howarth (1963) using figural after effects as an experimental measure of satiation also obtained findings which do not support predictions made using Eysenck's theory. However, it should be stressed that the theoretical predictions in all KAE and FAE-type experiments are based on the assumption that all experimental subjects were exposed to

identical sensory stimulation. This assumption is quite difficult to meet because of individual differences in reactive inhibition which tends to reduce effective sensory stimulation.

The findings in experiments using visual and kinesthetic satiation are also supported by experiments using semantic satiation. Das and Cook (1964) using association reaction time to highly associated word pairs found that satiated responses tended to shorten the subjects' association reaction time. This finding is contrary to predictions made from the basis of inhibition theory which would predict that satiation should lengthen association reaction time. In a later study Das (1966) found that ease of verbal conditioning depends on resistance to semantic satiation. Das suggests that the findings better support an attention theory of semantic conditioning rather than an inhibition type theory.

The hypothesis that extraverts will show greater reminiscence than will introverts has been tested by many researchers. Eysenck (1960) reported findings on several reminiscence scores that lend partial support for his theory. In this study the mean reminiscence score correlated $r = +.21$ with extraversion (significance level not reported). Eysenck and Eysenck (1960) feel that this low correlation demonstrates the great importance of experimental parameters as a major determinant of experimental results based on reminiscence measures. In this later study the reported correlation between reminiscence and extraversion under improved experimental conditions was $r = +.55$. Lynn (1960) supported these results reporting a significant correlation of $r = +.42$. Ray (1959) found no significant relationship between

performance level on the pursuit rotor and extraversion-introversion.

Brady (1966) attempted to evaluate differences in task persistence between extraverts and introverts. Using pursuit rotor and arm and leg ergometer performance as experimental measures, Brady obtained results which lend partial support to Eysenck's theoretical position.

In summary, the outcome of much early research has been aptly characterized by Becker (1960) who states:

> "There is very minimal evidence that some reactive inhibition measures co-vary with extraversion. However, there is equally compelling evidence to the contrary. . ."

The general inability of the Hull-Kimble-Eysenck two-factor theory of reminiscence to account for many of the experimental findings of perceptual motor performance led Eysenck (1965) to formulate a new theory which re-introduces the concept of consolidation in addition to the two factors of his earlier formulations, conditioned inhibition ($_sI_r$) and reactive inhibition (I_r). This theory has aptly been called a "three factor theory of reminiscence" (Eysenck, 1965).

Contemporary Phase: Eysenck's Three-Factor Theory

Eysenck's three-factor theory combines the essential features of the Kimble (1949)-Eysenck (1957) two-factor theory of inhibition, and the consolidation hypothesis of Muller and Pilzecker (reviewed in McGeoch and Irion (1952) and Hilgard and Bower (1966)). In its most recent form (Eysenck, 1965) this theory may be succinctly stated as

follows:

1. During pre-rest practice reactive inhibition (I_r) builds up and finally enforces Involuntary Rest Pauses (IRPs); the point at which the IRPs begin to occur depends on the drive level under which the subject is working. IRPs provide reinforcement for conditioned inhibition (sIr), which is the habit of non-performance in the task situation.

2. A programmed rest pause allows consolidation of the task "habit" to take place, following a negatively accelerated curve of acquisition; this provides the basis of the so called reminiscence phenomenon. The rest pause also allows ${}_sI_r$ to consolidate; this habit also follows a negatively accelerated curve of acquisition; the consolidation of ${}_sI_r$ provides the basis for the permanent work decrement.

3. Resumption of work after the rest pause produces extinction of ${}_sI_r$, due to non-reinforcement. Working against the post-pause upswing produced by this extinction process is the still continuing consolidation process. Consolidation and work can be thought of as mutually interfering processes. This interference produces post-rest downswing which ceases when consolidation is complete, and at this point we then return to the gentle upward sloping course characteristic of massed practice without rest pause interference.

As can readily be seen, Eysenck's use of conditioned inhibition is far better defined in this model than in the previous one. Conditioned inhibition in the present formulation is the habit of ceasing to respond rather than simply the habit of not responding as was

implied in Jones' (1958) revision of Hull's theory. This is a subtle change in Eysenck's viewpoint from his earlier position that conditioned inhibition was the opposite of habit strength. Similarly, reactive inhibition has become a drive to cease reacting, not just a drive to remain in the non-reactive state. These points are discussed by White (1968) who states:

> "We are distinguishing here, in both cases, between the state of not reacting, on one hand, and on the other, to the shift from the state of reacting to the state of not reacting. To me this suggests that we might consider explicitly two probabilities rather than the single one Hull considered. On one hand we might consider the probability that an I.R.P. will be inforced as a function of ${}_{s}I_{r}$ and I_{r}, which you will recall are, respectively, the habit of ceasing to react and the drive to cease reacting...on the other hand, we have the habit (${}_{s}H_{r}$) and the drive (D) relevant to the skill being acquired and here the requirement that zero drive imply no response would seem to suggest a multiplicative function (${}_{s}H_{r}$ x D)... We have in this sort of formulation an explicit split between the habit and drive associated with the acquisition of a skill and the habit and drive associated with the cessation of performance." (pp. 12 - 13)

This distinction between factors involved in task acquisition and factors involved in task performance contributes to what Eysenck terms the "Task specific features of reminiscence", the major factors of which are:

1. Tasks may be ordered along a continuum according to the amount of consolidation the performance of the task requires.

2. Tasks may be ordered along a continuum according to the degree to which they are likely to be influenced by I_r.

3. Tasks may be ordered according to the degree that task performance is influenced by the subject's motivation.

Tasks which involve new learning, such as the pursuit rotor, demonstrate both inhibition and consolidation effects, but prime importance is placed on the consolidation of new learning. For example, reminiscence in pursuit rotor learning is almost entirely due to consolidation (Rachman and Grassi, 1965). On the other hand, well practiced tasks or very simple psycho-motor tasks do not involve new learning and performance changes are more influenced by inhibitory effects than by the effects of consolidation. Performance changes in a task such as stylus tapping are almost entirely due to the spontaneous decay of I_r (Speilman, 1963; Eysenck, 1964B); in fact, it is difficult to understand what learning might be present in these sorts of tasks to be consolidated. Other types of tasks are intermediate, involving both the consolidation of new learning and performance induced inhibitory effects.

Tasks also differ in their relative sensitivity to the effects of inhibition. Self-paced tasks such as the pursuit rotor are relatively independent of inhibition effects because performance decrement caused by an IRP can be compensated for by extra-efficient performance in the inter-IRP periods. An externally-paced or experimenter-paced task, however, is greatly influenced by inhibition

effects since performance decrement during an IRP usually cannot be compensated for later due to the externally controlled nature of the task.

The effect of drive on tasks would seem to be greatly task specific. Tasks differ from each other along a fundamental property or quality of completeness. That is, some tasks are of a binary nature; they must be carried to completion; there is no minimum or incomplete stage. The items on intelligence tests are good examples of this sort of task - if the subject freely agrees to carry out the task at all, degree of motivation generally does not seem to greatly influence performance (Eysenck, 1944; Tiber and Kennedy, 1964). On other types of tasks various intermediate stages of performance exist. For example, in an inverted alphabet printing test, it is possible to complete a portion of the task and thus display intermediate performance.

In summary, Eysenck's present theory has several weaknesses. The most obvious weakness is that clear quantification of variables does not seem possible. The multiple factor nature of the theory would seem to somewhat limit the possibility of direct measurement of contributing variables. The complexity of the theory is such that the underlying hypothesized structures are generally studied through the effect they have on other measures. That is, instead of attempting to precisely measure I_r, at the present level of sophistication it is far more feasible to measure the "effect" of I_r on some ongoing process.

Another major difficulty is the task specific nature of many of the theoretical concepts which in turn is further confounded by the varying influence of drive on different types of tasks; however, in

spite of these difficulties, the three-factor theory possesses much greater ability to account for experimental findings (Eysenck, 1964A; Rachman and Grassi, 1965) than the Hull-Kimble-Eysenck two-factor theory which often cannot account for experimental findings in the field of psycho-motor learning. In addition, the three-factor theory provides a useful guide for the design of future experiments in this field and clearly demonstrates the level of complexity of what at first appraisal seem relatively simple phenomena.

Because the presence of reactive inhibition and of conditioned inhibition confounds and interferes with measures of reminiscence, consolidation, and performance decrement, the design trend in most studies linking extraversion-introversion with psycho-motor performance has been to design the study so as to attenuate the inhibitory effects as much as is possible. This trend was especially reinforced by Eysenck's (1964A, 1965) statements concerning the differential susceptibility of different psycho-motor tasks to inhibition and consolidation effects.

Eysenck (1965) and Broadbent (1953) suggested that vigilance tests, reaction time tests, and allied experimenter-paced tasks would be very prone to the effects of reactive inhibition, for the reason that if a stimulus occurs during the Involuntary Rest Period (IRP), the subject will not be able to respond to it; as opposed to pursuit rotor performance and other subject-paced tasks in which responses lost during an IRP could be made up during the period following the IRP. Stimulus signal duration is also an important factor, for a short duration stimulus occurring during an IRP would have ceased to be present when the IRP

ended, causing performance decrement. On the other hand, a long duration stimulus would still be present at the end of the IRP, and would therefore be noted by the subject; a response would be made, and no performance decrement would occur. This task "sensitivity" is especially evident in subject-paced tasks where performance decrement during an IRP can be compensated for by super-efficacious performance in the inter-IRP period. In a study reported by Speilman (1963) using stylus tapping as the psycho-motor task, the amount of time that the tapping stylus was in contact with a fixed metal rest plate ("tap" time) was compared with the amount of time that the stylus was away from the metal plate ("gap" time). IRPs were scored in terms of discontinuity in the subjects' "gap" times. Speilman found that the observed frequency of IRPs was fifteen times greater in the extravert group than in the introvert group. The onset of IRPs was also significantly earlier ($p < .01$) in the extravert group than in the introvert group. The results of this study were confirmed by Eysenck (1964B) who found a high positive correlation between extraversion and IRPs.

In the case of this type of task, the effects of reactive inhibition (I_r) produce a slowing down of the tapping rate, terminating in an IRP; but, this performance decrement can be "averaged out" by a particularly rapid rate of tapping following an IRP. The surprising effect of this is that while extraverts have far more numerous IRP occurrences than introverts their actual performance in terms of production of taps is not significantly different from the performance of introverts (Speilman, 1963; Eysenck, 1964B).

Similar results in an experimenter-paced task were reported by Bakan, Belton, and Toth (1963). In a study of the relationship of extraversion-introversion and performance decrement during an auditory vigilance task, the researchers found that while the initial performance of the extravert group was higher than that of either the normal (control) or the introvert group, it rapidly deteriorated to a significantly lower level than that of the introvert group. However, both the initial and the terminal level of performance in the normal group was lower than that of the extravert group although the performance difference was not significant. Another finding not commented on by the authors, and which demonstrates that the effects of inter-IRP compensation may even be present in an experimenter-paced task, was that there was no significant difference in the mean number of signals (averaged over the total test period) detected by the three groups. It is only when the forty-eight minute total time period is divided into three sixteen minute observational periods that the decline in the performance of the extravert group, as compared with the performance of the introvert group becomes obvious.

Fraser (1958), referring to his experimental studies of performance decrement, provides an apt conclusion to this portion of our discussion.

> "It appears, then, that if we are looking for the effects of prolonged work in any field we need to adopt a rather sophisticated approach to the problem. A simple examination of average output or before-after changes may prove very deceptive.

Thus some of the earlier workers in this field sometimes found that performance on some isolated tests actually was improved after a long spell of hard flying. We need to know what sort of distinguishing features are most likely to give us a precise idea of what is happening as the individual becomes fatigued....."

CHAPTER II

STATEMENT OF THE PROBLEM AND EXPERIMENTAL DESIGN

STATEMENT OF THE PROBLEM

The design trend in most psycho-motor performance studies reflects an interest in total work output; therefore, the majority of studies dealing with vigilance have used performance measures with relatively long time bases. As an example, a usual method of manipulating data in vigilance studies has been succinctly stated by Mackworth (1950):

> "A study of the results of Clock Tests... suggests that a negatively accelerated curve was usually found, provided that the data had been smoothed and the minute-by-minute effects statistically abolished by averaging the frequency of missed responses for each half hour; i.e. this finding refers therefore to the broad trend rather than to minor fluctuations in accuracy." (p.259)

Differential inhibition effects between different personality types constitute a major premise of Eysenck's theory and the principal manifestation of these effects is performance loss caused by involuntary rest pauses. The use of "broad trend" measures in many psycho-motor performance studies involving experimental populations selected on the basis of personality type may not constitute an adequate measure of performance. This inappropriate choice of measures by experimenters may account for many of the so-called failures to find evidence of performance decrement in long and intermediate stimulus duration tasks such as the pursuit rotor, and dynamometer-type measures where the performance decrement is summed over a relatively long period of time (Brady, 1966).

Using a short stimulus duration character recognition task, Hogan (1966) found significant differences between the performance of introverts and the performance of extraverts on the Continuous Performance Test (CPT) developed by Rosvold et. al.(1956). The results of Hogan's study suggest that the concept of reactive inhibition as applied by Eysenck may be used to explain performance differences between introverts and extraverts on a visual vigilance task. However, the following criticisms of Hogan's experiment may be made.

1. The subjects were all female, and McPherson (1965) reports that a significant interaction between gender "female" and extraversion was found in the 1957 work of Brebner; therefore, a sex-linked experimental bias may have occurred.

2. The subjects were equated for task motivation on a motivational scale, the validity of which has not been demonstrated. While this type of task may not be critically sensitive to the subjects' drive state (Eysenck, 1965), the absence of clear evidence as to just what Hogan measured makes the use of that test score as a covariate in subject blocking or other statistical operations doubtful.

3. No measure was made of the subjects' performance failures. That is, a missed stimulus was recorded only when the subjects' reaction times exceeded the CPT apparatus' fixed criterion of performance decrement (the subject must respond within 0.69 seconds of stimulus onset), a result which suggests that many IRPs went unrecorded.

4. The lack of a 'normal' control group. The experimental hypothesis rests on a difference being found between the experimental groups. However, this difference must be greater than the difference between either experimental group and a normal group because of the central position of the normal group on the E-I personality dimension. Lacking such a group, Hogan has been unable to demonstrate that his experimental groups differ from a normal population.

5. The CPT task may not be difficult enough. The typically reported percentages of correct responses of normal populations are in the order of 98.67% (Townsend and Mirsky, 1960) and 95.43% (Mirsky et. al., 1959); whereas, the reported incidence of correct responses in many visual vigilance studies is in the order of 75.85% (Mackworth, 1961).

It would seem from the above findings that there exists a need for further consideration of the nature of IRPs and their occurrence in a repetitive perceptual-motor vigilance task; therefore, we have conducted the following experiment.

EXPERIMENTAL DESIGN

Experimental Measures

This study will attempt to investigate the extent to which individuals, classified according to the personality dimension introversion-extraversion, differ in their performance on a modified version of the Continuous Performance Test, evaluated by the following experimental measures:

1. The subject reaction time is measured from stimulus onset to the subject's depressing the response key.

2. Missed Responses: the number of subject reaction times exceeding 0.99 seconds in duration.

3. Invalid Responses: the number of responses made by the subject to incorrect (non-critical) stimuli.

Experimental Hypotheses

Hypothesis 1

In accord with Eysenck's theory, we predict that extraverts will demonstrate increasingly greater performance decrement than introverts in the pre-rest phase of the experiment due to the more rapid onset and greater production of reactive inhibition effects in

extraverts as compared with introverts. For the purposes of experiment performance decrement will be evaluated by two measures; missed responses and reaction time and reaction time to critical stimuli.

Specifically, we predict that extraverts will demonstrate significantly more missed responses and significantly longer reaction times than will introverts in the pre-rest experimental periods. Further, the rate of increase in reaction times will be much greater in extraverts than in introverts during this experimental phase.

Hypothesis 2

Also, in accord with Eysenck's theory we predict that extraverts will demonstrate significantly greater reminiscence (performance recovery) than will introverts in the post-rest experimental phase. This effect will be evaluated by the same measures of performance that are used in Hypothesis 1: reaction time, and missed responses.

The specific prediction for this hypothesis is that extraverts will show a significantly greater decrease in post-rest reaction time and number of missed responses compared with pre-rest experimental values than will introverts.

Hypothesis 3

Following the findings of Spielman (1963) and Eysenck (1964B) which suggest that subjects attempt to compensate for IRP blocking by increased performance following IRP induced performance failure, we

predict that extraverts, having a higher incidence of IRP blocking than introverts, will demonstrate greater attempts at compensatory performance than introverts. Because the present experiment is an experimenter-based task, any attempts to increase performance may well result in an increase in anticipatory errors and other errors due to the subject making inappropriate or invalid responses. That is, as performance decrement increases, the subjects' attempts at compensating for performance failure should result in an increase in the number of inappropriate responses. Specifically, we predict that extraverts will make more invalid responses than will introverts and that the incidence of invalid responses will increase as performance decrement increases.

In addition to this hypothesis, and with regard to our second hypothesis, we would predict that in the post-rest experimental phase, extraverts who dissipate I_r faster than introverts during a programmed rest period will have fewer IRPs, reducing the need for performance failure induced compensation, and therefore, make fewer invalid responses than in the pre-rest experimental period. Because introverts have a far smaller incidence of IRPs, we would not extend this prediction to the introvert group.

Specifically, we predict that extraverts will show a significant difference in the number of post-rest invalid responses compared with pre-rest values of this measure, but that introvert group will not demonstrate a significant difference in this measure.

Hypothesis 4

A general prediction based on a logical extension of Eysenck's theory is that the intermediate position of the normal group on the E-I personality demension should result in the task performance of the normal group falling between the performance of the extravert group and the performance of the introvert group.

Apparatus

The Continuous Performance Test:

The Continuous Performance Test (CPT) developed by Rosvold et. al. (1956) is a task that requires a high level of continuous vigilance over an appreciable period of time. The apparatus consists essentially of a revolving drum on which two series, each of thirty-one stimuli are mounted side by side. The drum revolves slowly, about twice a minute, in a box-like case equipped with a visor through which the subject is required to look. The experimenter can shift from the right list to the left list at will by sliding a shutter so as to cover one list or the other. The letters are illuminated briefly (.25 sec.) by a neon bulb. The subject performs by pressing a response key when certain "correct" (critical) stimuli appear. Failure of the subject to respond to the critical stimuli is scored as a "missed" response. If the subject responds to an "incorrect" (non-critical) stimulus, an "invalid" response is recorded.

For this experiment a conventional CPT apparatus was modified as follows:

The single letter stimulus was replaced by a 2 x 2 matrix of four different symbols. The symbols were drawn at random from a group of ten symbols using a computerized random assignment process. Thirty-one of these matrices were presented at random to the subject. Of these thirty-one stimuli, six contained a pair of identical symbols. Those matrices containing a pair of symbols are referred to as critical symbols and the subject was instructed to respond only in the presence of these symbols (see Appendix A for details). Two display panels each containing a series of thirty-one stimuli were alternately used to reduce serial learning effects. The onset of a critical stimulus starts a clock timer which stops when the subject depresses the response key.

If the subject fails to respond within one second of stimulus onset, the apparatus is automatically reset and a "missed response" error is recorded. Responding by the subject at any time except during the one second period following a critical stimulus is scored as an "invalid response".

The selection instrument:

The Eysenck Personality Inventory (EPI) (Eysenck and Eysenck, 1964) was used as the basis for the selection of the experimental subjects and their division into three experimental groups. This test was developed to measure two dimensions of personality: extraversion-introversion and neuroticism. The N and E factors are independent (orthogonal) dimensions of personality and both are in turn independent of intelligence (Eysenck, 1967).

Subjects

Selection of Subjects:

The Eysenck Personality Inventory (EPI) was administered to approximately 400 students enrolled in the introductory psychology class, and an additional 50 students enrolled in the second year Psychology of Personality course at the University of Alberta. From this group, thirty students were selected, grouped according to the following EPI test score criteria:

a - Introverts, n=10 having EPI "E" scale scores less than 7.

b - Extraverts, n=10 having EPI "E" scale scores greater than 17.

c - Normal (control group), n=10 having EPI "E" scale score of less than 13, but greater than 11.

All subjects were selected from a population having an EPI "N" score falling within plus or minus one standard deviation of the general population "N" scale mean given in the table of published norms for the EPI (Eysenck and Eysenck, 1964) in order to minimize the confounding of the experimental measure by neuroticism. Table II-1 summarizes the EPI data on the experimental subjects.

TABLE II-1

SUMMARY OF EPI DATA ON SUBJECTS

	DESCRIPTIVE STATISTIC	EXTRAVERTS	CONTROLS	INTROVERTS
	Number of subjects	10	10	10
"E" Scale	Mean	19.2	11.5	5.8
	Variance	2.89	0.72	1.96
	Standard deviation	1.69	0.85	1.40
	Median	19	11	6.5
"N" Scale	Mean	8.3	8	9
	Variance	22.01	32.49	28.89
	Standard deviation	4.69	5.70	5.37
	Median	10	8.5	10.5

Procedure

Instructions to the Subjects - Practice Task:

The subjects were assigned at random to appointment times in either a morning (1000 to 1130 hours) session or an afternoon (1400 to 1630 hours) session. The subject was first given a sheet of paper on which were printed a set of ten matrices made up of the same symbols used as stimuli in the CPT part of the study. All subjects were given standard instructions as follows:

> "Here are a series of groups of symbols. I would like you to place an 'x' under the groups that contain a pair of triangles. These sheets are for practice only, they are not scored, and you do not have to put your name on them. Do you have any questions?"

In this task the subjects are asked to do exactly the same sort of task that they will be doing in the CPT part of the study; that is, they are asked to respond only in the presence of an identical pair of stimuli, two triangles. This task, in addition to teaching the subjects what they are to do in the test situation, aids in reducing anxiety arising from the experimental situation.

The actual experimental procedure using the CPT can be divided into three phases. These are:

1. Pre-rest experimental period.
2. A ten-minute rest period.
3. Post-rest experimental period.

The Pre-Rest Experimental Period:

When the subject has completed the practice task, he is seated before the CPT and given the following instructions:

> "Now you will be doing the same task that you did before, only this time, the groups of four symbols will be projected one at a time on this screen. Whenever one of these groups contains two triangles, press this button. Do not hold the button any time other than after a group containing two triangles. Since the groups follow one another at timed intervals, try to respond as soon as you can. To keep from tiring your eyes, we will switch from one side to another during the experiment, and there will be a rest period during the experiment. Do you have any questions? Now, tell me what you are to do?"

All subjects are then given one trial of thirty stimulus presentations (six presentations of the critical stimulus) to acquaint

them with the apparatus. After this practice trial, each subject was given 30 trials (180 presentations of the critical stimulus). This block of thirty trials was the "pre-rest phase" of the experiment and was followed by a ten-minute rest period.

The Rest Period:

The duration of the rest period was ten minutes. During this period the subject was allowed to relax and was given a seat in a comfortable arm chair. A number of books were available for the subjects' perusal. The subjects were not allowed to leave the experimental room during the rest period.

The Post-Rest Experimental Period:

The rest period was followed by a further block of ten trials (sixty presentations of the critical stimulus). Subjects were then asked to comment on the experiment, and the purpose of the experiment was explained. The experimental hypotheses and the subjects' EPI results were discussed in general terms but the specific predictions of the experiment were discussed in a general, "informational" way rather than in a more definitive manner. The subjects were urged to discuss their feelings about the experimental procedure and their experiences during their period of participation in the experiment.

CHAPTER III

EXPERIMENTAL RESULTS

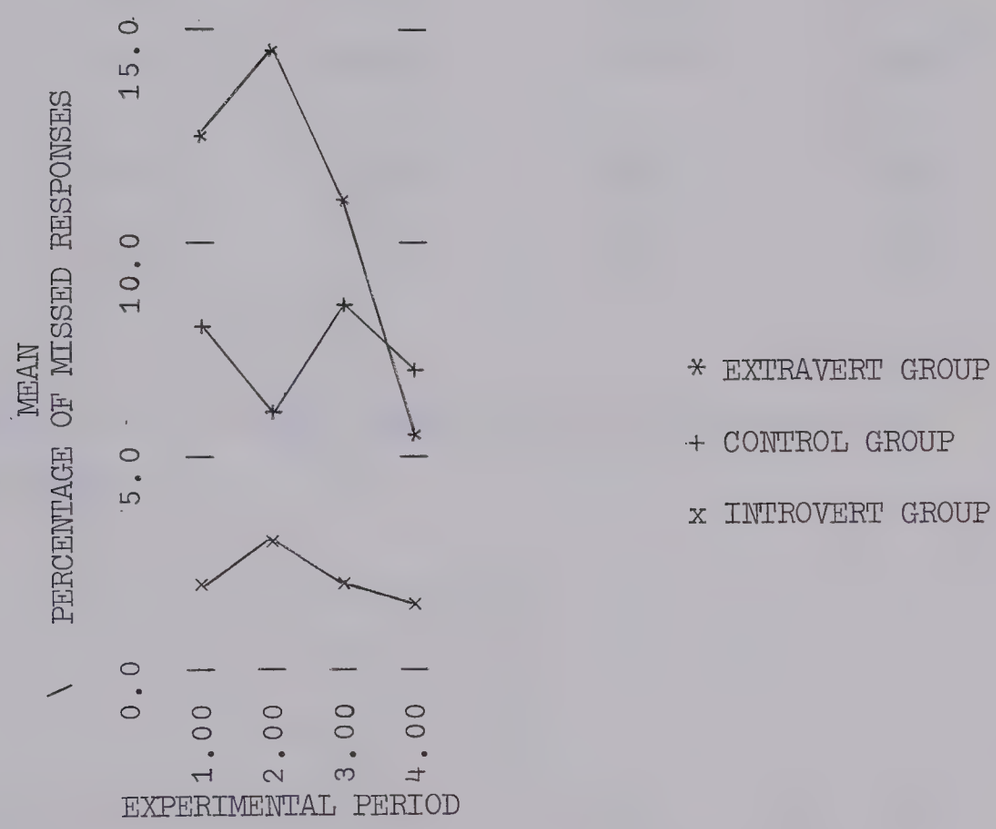
The data presentation of the experimental results is arranged according to the experimental measure being used. The experimental measures are presented and analyzed in the following order: Missed Responses, Invalid Responses, and Subject Reaction Times.

The discussion of the experimental results is to be found in Chapter IV, "Discussion of Results", immediately following the present chapter.

MEASURE ONE: MISSED RESPONSES

The percentages of missed responses for the three experimental groups during each of the experimental periods are given in Figure III-1.

FIGURE III-1



MEAN PERCENTAGE OF MISSED RESPONSES

FOR EACH EXPERIMENTAL PERIOD

The descriptive statistics of the missed response measure are given in Table III-1.

TABLE III-1

SUMMARY OF MISSED RESPONSE DATA

DESCRIPTIVE STATISTIC	ALL SUBJECTS	EXTRAVERTS	CONTROLS	INTROVERTS
Number of Subjects	30	10	10	10
Mean	4.10	6.55	4.45	1.30
Variance	14.71	23.89	4.72	1.96
Standard Deviation	3.84	4.89	2.17	1.40
Median	3.50	6.00	4.50	1.00

The analysis of variance summary table for all groups is given in Table III-2.

TABLE III-2

ANALYSIS OF VARIANCE SUMMARY TABLE

MISSED RESPONSES: ALL GROUPS

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Extraversion	2	558.6	558.6	13.29	<.005
Subject Sex (S)	1	26.13	26.13	1.24	(N.S.)
E x S	2	47.27	23.63	1.13	(N.S.)
Ss w. E w. S	24	504.3	21.01	--	--
Periods	3	63.27	21.09	3.68	<.025
E x P	6	111.53	18.59	3.25	<.01
S x P	3	10.47	3.49	0.61	(N.S.)
E x S x P	6	17.13	2.86	0.50	(N.S.)
P x Ss w. E w. S	72	412.1	5.72	--	--
TOTAL	119	1750.8			

The information on missed responses given in Table III-1 which was obtained from the data supermatrix can be broken down into three matrices, one for each of the experimental groups. The summary tables of the analysis of variance of missed responses for each of the experimental groups are given in Tables III-3, III-4, and III-5.

TABLE III-3

ANALYSIS OF VARIANCE SUMMARY TABLE

MISSED RESPONSES: EXTRAVERT EXPERIMENTAL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	72.9	72.9	1.37	(N.S.)
Ss within S	8	426.0	53.25	--	--
Periods (P)	3	156.5	52.17	4.59	<.025
S x P	3	3.7	1.23	0.11	(N.S.)
P x Ss within S	24	272.8	11.37	--	--
TOTAL	39	931.9			

TABLE III-4

ANALYSIS OF VARIANCE SUMMARY TABLE

MISSED RESPONSES: CONTROL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	0.4	0.4	0.081	(N.S.)
Ss within S	8	39.5	4.94	--	--
Periods (P)	3	14.7	4.9	1.11	(N.S.)
S x P	3	23.6	7.87	1.94	(N.S.)
P x Ss within S	24	105.7	4.40	--	--
TOTAL	39	183.9			

TABLE III-5

ANALYSIS OF VARIANCE SUMMARY TABLE

MISSED RESPONSES: INTROVERT EXPERIMENTAL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	0.1	0.1	0.021	(N.S.)
Ss within S	8	38.8	4.85	--	--
Periods (P)	3	3.6	1.2	0.857	(N.S.)
S x P	3	0.3	0.1	0.071	(N.S.)
P x Ss within S	24	33.6	1.4	--	--
TOTAL	39	76.4			

Scheffé (1953) has developed a procedure for making any and all comparisons of interest between a set of means. Using this procedure we do not have to plan the comparisons in advance. Of course, Scheffé's test can be used for testing à priori orthogonal comparisons. However, when used with à priori comparisons Scheffé's test becomes extremely conservative. In other words, larger differences will be required for significance than with other procedures. Scheffé (1953) suggests that with his test one might consider setting the alpha level = .10 instead of alpha = .05.

The conservative aspects of Scheffé's procedure are more than compensated for by its constant error rate. Using Scheffé's test for multiple comparisons the probability that all statements concerning significance are correct is equal to 1 - alpha. Thus if alpha = .05, the probability that all statements yielded by the procedure are correct

will be equal to, or greater than .95. For further information on this procedure the reader is referred to the excellent reviews by Edwards (1963) and Rule (1969).

The principal analysis of variance on the missed response data indicates that the levels of extraversion effect were significant (Table III-2). Using Scheffé's test, a systematic comparison of the three levels of extraversion was made. The results of this comparison are given in Table III-6.

TABLE III-6

SUMMARY TABLE SCHEFFE'S TEST

MISSED RESPONSES: LEVELS OF EXTRAVERSION

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
E vs. C	88.2	2.10	(N.S.)
E vs. I	551.25	13.12	<.005
C vs. I	198.45	4.72	<.025
Average of C + I vs. E	360.15	8.57	<.005
Average of E + C vs. I	470.4	11.19	<.005
Average of E + I vs. C	7.35	0.18	(N.S.)

The same analysis also indicates that the experimental period effect was significant; therefore, a comparison of the mean missed response scores in each experimental period was performed. The results of the comparisons of experimental periods using Scheffé's method are given in Table III-7.

TABLE III-7

SUMMARY TABLE SCHEFFE'S TEST

MISSED RESPONSES: EXPERIMENTAL PERIODS FOR ALL SUBJECTS

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
1 vs. 2	0.42	0.02	(N.S.)
1 vs. 3	0.82	0.05	(N.S.)
1 vs. 4	41.67	2.42	(N.S.)
2 vs. 3	2.40	0.14	(N.S.)
2 vs. 4	50.42	2.93	$<.05$
3 vs. 4	30.82	1.79	(N.S.)
Average of 1 + 2 vs. 4	61.25	3.56	$<.025$
Average of 1 + 3 vs. 4	48.05	2.79	$<.05$
Average of 2 + 3 vs. 4	53.36	3.10	$<.05$
Average of 1 + 2 + 3 vs. 4	60.84	3.54	$<.025$
Average of 1 + 2 + 4 vs. 3	1.6	0.09	(N.S.)
Average of 1 + 3 + 4 vs. 2	14.4	0.84	(N.S.)
Average of 2 + 3 + 4 vs. 1	7.51	0.44	(N.S.)

Of the analyses of variance performed on the data matrices obtained from the missed response data for each of the experimental groups (Tables III-3, III-4 and III-5) only the analysis of variance on the extravert data yielded statistically significant results (Table III-3).

In the extravert experimental group, the experimental periods main effect is significant. Using Scheffé's test, comparisons of the experimental period mean missed response score in each experimental period were made. The results of this procedure are given in Table III-8.

TABLE III-8

SUMMARY TABLE SCHEFFE'S TEST

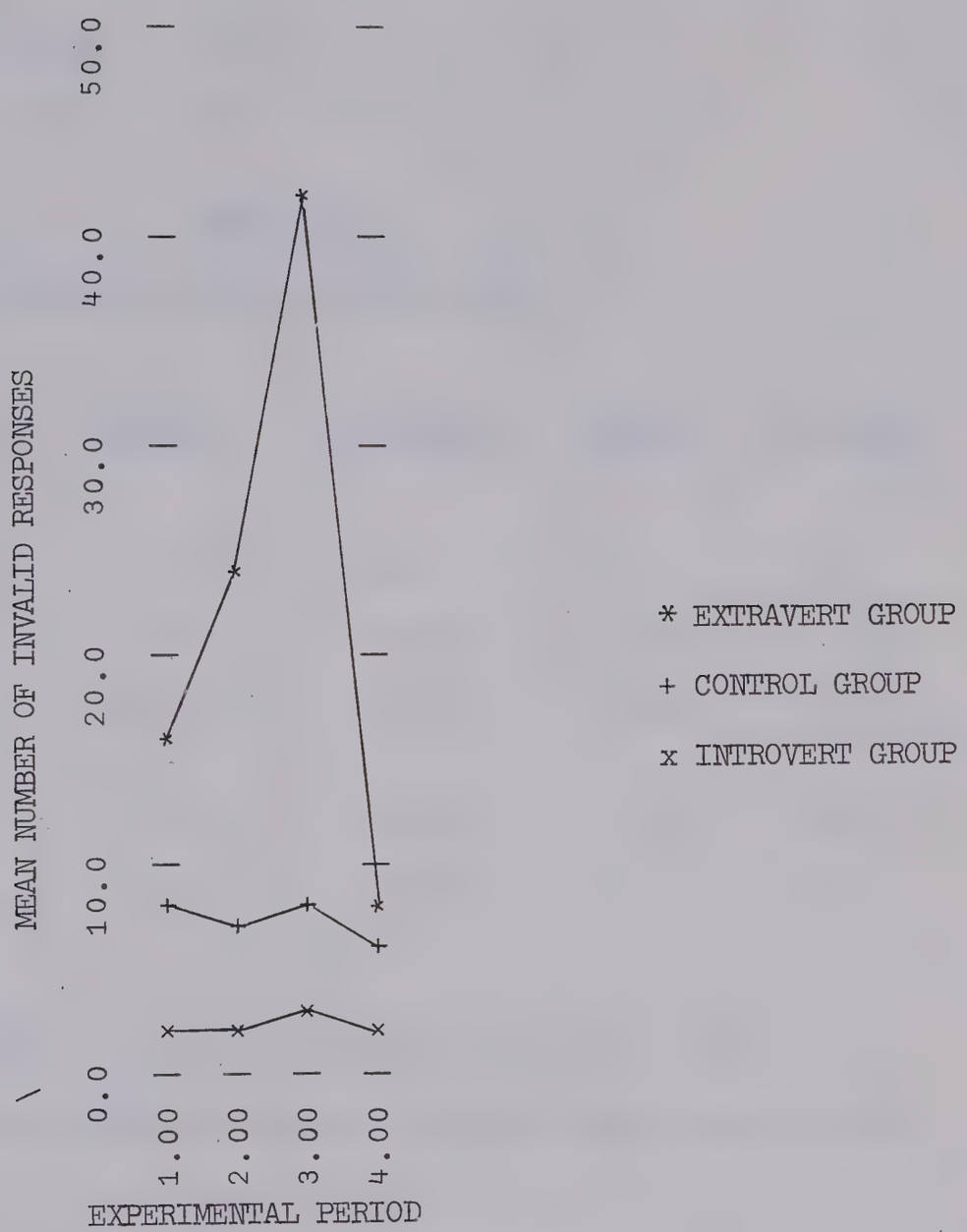
MEAN MISSED RESPONSE SCORE DURING EXPERIMENTAL PERIODS -

EXTRAVERT GROUP

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
1 vs. 2	6.05	0.18	(N.S.)
1 vs. 3	6.05	0.18	(N.S.)
1 vs. 4	88.2	2.59	(N.S.)
2 vs. 3	24.2	0.71	(N.S.)
2 vs. 4	140.45	4.12	<.025
3 vs. 4	48.05	1.41	(N.S.)
Average of 1 + 2 vs. 4	150.42	4.41	<.025
Average of 1 + 3 vs. 4	88.82	2.60	(N.S.)
Average of 2 + 3 vs. 4	117.6	3.45	<.05
Average of 1 + 2 + 3 vs. 4	132.3	3.88	<.025
Average of 1 + 2 + 4 vs. 3	0.03	0.001	(N.S.)
Average of 1 + 3 + 4 vs. 2	61.63	1.81	(N.S.)
Average of 2 + 3 + 4 vs. 1	14.7	0.43	(N.S.)

From Tables III-4 and III-5 it can be seen that there were no significant main or interaction effects in the analyses of variance performed on the missed response data obtained from the control and introvert groups. Therefore, Scheffé's procedure was not used to evaluate this data since if the mean square between groups is not significant then no comparison made using Scheffé's procedure can be significant (Rule, 1969).

FIGURE III-2



MEAN NUMBER OF INVALID RESPONSES

FOR EACH EXPERIMENTAL PERIOD

MEASURE TWO: INVALID RESPONSES

The mean number of invalid responses for the three experimental groups during each of the experimental periods is graphically presented above in Figure III-2.

The descriptive statistics of the invalid response measure are given in Table III-9.

TABLE III-9

SUMMARY OF INVALID RESPONSE DATA

DESCRIPTIVE STATISTIC	ALL SUBJECTS	EXTRAVERTS	CONTROLS	INTROVERTS
Number of Subjects	30	10	10	10
Mean	10.65	22.50	7.03	2.43
Variance	198.73	351.38	22.64	5.48
Standard Deviation	14.10	18.75	4.75	2.34
Median	5.5	15.5	6	2

The results of an analysis of variance on the invalid response data for all groups are given in summary form in Table III-10.

TABLE III-10

ANALYSIS OF VARIANCE SUMMARY TABLE

INVALID RESPONSES: ALL GROUPS

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Extraversion (E)	2	8848.55	4424.28	32.54	<.005
Subject Sex (S)	1	3.33	3.33	0.03	(N.S.)
E x S	2	77.32	38.66	0.28	(N.S.)
Ss w. E w. S	24	3263.1	135.96	--	--
Periods (P)	3	2247.63	749.21	10.71	<.005
E x P	6	3822.32	637.05	8.56	<.005
S x P	3	12.87	4.29	0.06	(N.S.)
E x S x P	6	18.08	3.01	0.04	(N.S.)
P x Ss w. E w. S	72	5356.1	74.39	--	--
TOTAL	119	23649.3			

This data supermatrix may be reduced to three component matrices, one for each of the experimental groups. A repeated measures analysis of variance was performed on each of these matrices. The results of these analyses of variance are summarized in Tables III-11, III-12 and III-13.

TABLE III-11

ANALYSIS OF VARIANCE SUMMARY TABLE

INVALID RESPONSES: EXTRAVERT EXPERIMENTAL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	14.4	14.4	0.04	(N.S.)
Ss within S	8	2656.1	332.01	--	--
Periods (P)	3	6046.6	2015.53	9.71	<.005
S x P	3	3.0	1.0	0.01	(N.S.)
P x Ss within S	24	4983.9	207.66	--	--
TOTAL	39	13704.0			

TABLE III-12

ANALYSIS OF VARIANCE SUMMARY TABLE

INVALID RESPONSES: CONTROL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	65.03	65.03	1.01	(N.S.)
Ss within S	8	472.2	59.03	--	--
Periods (P)	3	22.28	4.43	0.60	(N.S.)
S x P	3	27.68	9.23	0.75	(N.S.)
P x Ss within S	24	295.8	12.33	--	--
TOTAL	39	882.98			

TABLE III-13

ANALYSIS OF VARIANCE SUMMARY TABLE

INVALID RESPONSES: INTROVERT EXPERIMENTAL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	1.23	1.23	0.07	(N.S.)
Ss within S	8	134.8	16.85	--	--
Periods (P)	3	1.08	0.36	0.11	(N.S.)
S x P	3	0.28	0.10	0.03	(N.S.)
P x Ss within S	24	76.4	3.18	--	--
TOTAL	39	213.78			

The principal analysis of variance (Table III-9) indicated that the levels of extraversion main effect and the experimental periods main effect were statistically significant. Using Scheffé's procedure a systematic comparison of the subjects' mean invalid response score for the three levels of extraversion and for the four experimental periods was made. The results of these comparisons are given in Table III-14 and in Table III-15.

TABLE III-14

SUMMARY TABLE SCHEFFE'S TEST

MEAN INVALID RESPONSES BETWEEN LEVELS OF EXTRAVERSION

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
E vs. C	4789.51	17.61	<.005
E vs. I	8060.11	29.64	<.005
C vs. I	423.20	1.56	(N.S.)
Average C + I vs. E	8425.35	30.98	<.005
Average E + C vs. I	4059.04	14.93	<.005
Average E + I vs. C	788.44	2.90	(N.S.)

TABLE III-15

SUMMARY TABLE SCHEFFE'S TEST

MEAN INVALID RESPONSES DURING EXPERIMENTAL PERIODS

FOR ALL GROUPS

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
1 vs. 2	70.42	0.32	(N.S.)
1 vs. 3	1109.4	4.97	<.005
1 vs. 4	156.82	0.70	(N.S.)
2 vs. 3	620.82	2.78	<.05
2 vs. 4	437.4	1.96	(N.S.)
3 vs. 4	2100.42	9.41	<.005
Average of 1 + 2 vs. 4	372.67	1.67	(N.S.)
Average of 1 + 2 vs. 3	1130.01	5.06	<.005
Average of 1 + 3 vs. 4	1135.02	5.09	<.005
Average of 2 + 3 vs. 4	1484.94	6.66	<.005
Average of 1 + 2 + 3 vs. 4	1047.21	4.69	<.025
Average of 1 + 2 + 4 vs. 3	1804.54	8.09	<.005
Average of 1 + 3 + 4 vs. 2	3.21	0.14	(N.S.)
Average of 2 + 3 + 4 vs. 1	141.88	0.64	(N.S.)

From the information given in Table III-11 it can be seen that within the invalid response data matrix obtained from the extravert group, only the experimental periods main effect is statistically signi-

ficant. Using Scheffé's test, comparisons of the mean invalid response score for each experimental period were made. The results of these comparisons are given in Table III-16.

TABLE III-16

SUMMARY TABLE SCHEFFE'S TEST

MEAN INVALID RESPONSE SCORE DURING EXPERIMENTAL PERIODS -

EXTRAVERT GROUP

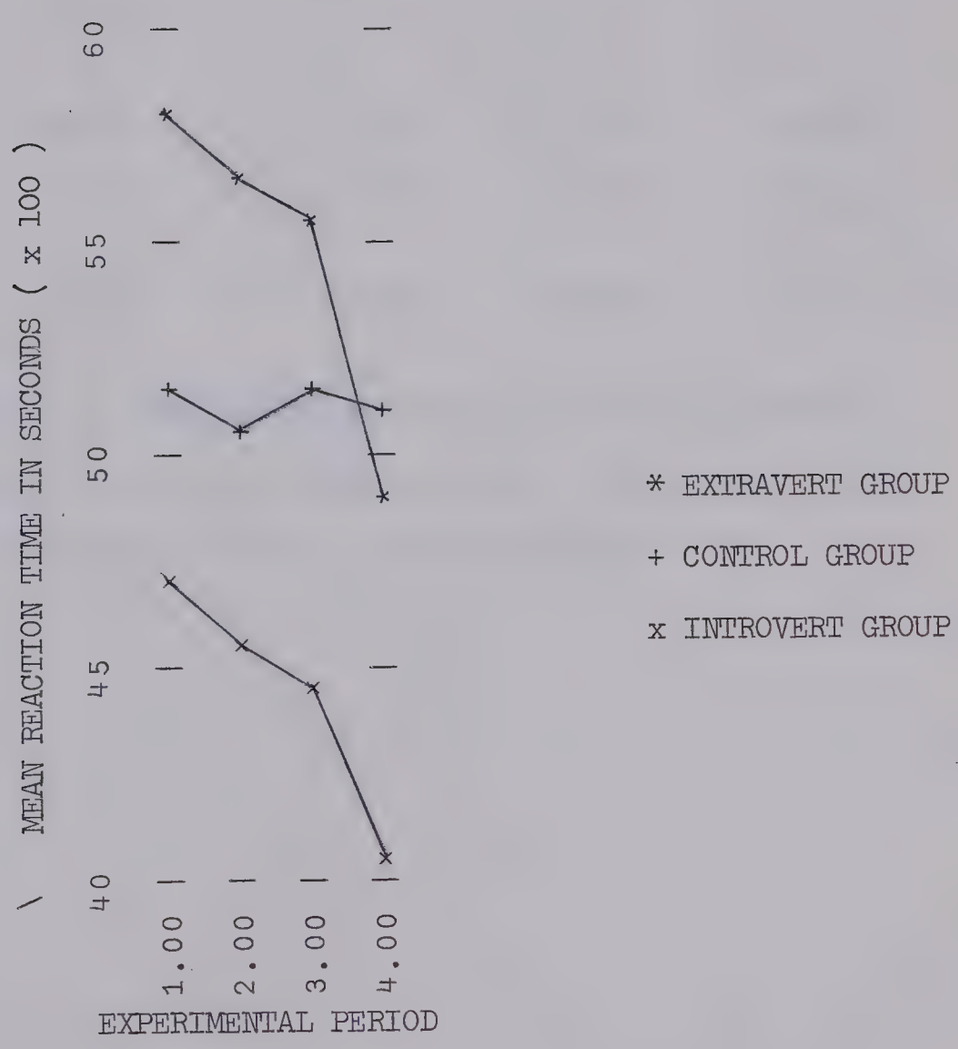
COMPARISON	MEAN SQUARE DIFFERENCE	F	P
1 vs. 2	281.25	0.45	(N.S.)
1 vs. 3	3150.05	5.06	<.025
1 vs. 4	336.20	0.54	(N.S.)
2 vs. 3	1548.80	2.49	(N.S.)
2 vs. 4	1232.45	1.98	(N.S.)
3 vs. 4	5544.45	8.90	<.005
Average of 1 + 2 vs. 4	952.02	1.53	--
Average of 1 + 2 vs. 3	3038.82	4.88	<.025
Average of 1 + 3 vs. 4	2870.42	4.61	<.025
Average of 2 + 3 vs. 4	4001.67	6.42	<.005
Average of 1 + 2 + 3 vs. 4	2726.53	4.38	<.025
Average of 1 + 2 + 4 vs. 3	4813.33	7.73	<.005
Average of 1 + 3 + 4 vs. 2	26.13	0.04	(N.S.)
Average of 2 + 3 + 4 vs. 1	496.13	0.80	(N.S.)

The analyses of variance for the Control Group (Table III-12) and for the Introvert Group (Table III-13) indicate that for these two groups there were no statistically significant main or interaction effects; therefore, no further analyses of these data matrices were carried out.

MEASURE THREE: SUBJECT REACTION TIME

The mean subject reaction times for the three experimental groups during each of the experimental periods are graphically presented in Figure III-3.

FIGURE III-3



MEAN SUBJECT REACTION TIME

FOR EACH EXPERIMENTAL PERIOD

The descriptive statistics of the reaction time measure are given in Table III-17.

TABLE III-17

SUMMARY OF REACTION TIME DATA

DESCRIPTIVE STATISTIC	ALL SUBJECTS	EXTRAVERTS	CONTROLS	INTROVERTS
Number of Subjects	30	10	10	10
Mean	0.465	0.493	0.472	0.430
Variance	0.006	0.007	0.001	0.003
Standard Deviation	0.077	0.084	0.032	0.055

An analysis of variance was performed on the mean reaction time for each subject in each experimental period. The summary table of this analysis of variance is to be found in Table III-18.

TABLE III-18

ANALYSIS OF VARIANCE SUMMARY TABLE

REACTION TIME: ALL GROUPS

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Extraversion (E)	2	0.22931	0.11465	10.52	<.005
Subject Sex (S)	1	0.00017	0.00017	0.02	(N.S.)
E x S	2	0.00359	0.00179	0.17	(N.S.)
Ss w. E w. S	24	0.26149	0.01090	--	--
Periods (P)	3	0.04413	0.01471	12.97	<.005
E x P	6	0.02444	0.00407	3.59	<.005
S x P	3	0.00093	0.00031	0.27	(N.S.)
E x S x P	6	0.01143	0.00191	1.68	(N.S.)
P x Ss w. E w. S	72	0.08164	0.00113	--	--
TOTAL	119	0.65712			

The supermatrix of subject mean reaction time was divided into three components, one for each of the experimental groups and the resulting data matrices were analyzed. The summaries of these analyses of variance are given in Tables III-19, III-20 and III-21.

TABLE III-19

ANALYSIS OF VARIANCE SUMMARY TABLE

REACTION TIME: EXTRAVERT EXPERIMENTAL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	0.00317	0.00317	0.152	(N.S.)
Ss within S	8	0.16677	0.02085	--	--
Periods (P)	3	0.04701	0.01567	8.595	<.005
S x P	3	0.00438	0.00146	0.80	(N.S.)
P x Ss within S	24	0.04375	0.00182	--	--
TOTAL	39	0.26509			

TABLE III-20

ANALYSIS OF VARIANCE SUMMARY TABLE

REACTION TIME: CONTROL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	0.00039	0.00039	1.01	(N.S.)
Ss within S	8	0.00310	0.00039	--	--
Periods (P)	3	0.00078	0.00026	0.28	(N.S.)
S x P	3	0.00264	0.00088	0.96	(N.S.)
P x Ss within S	24	0.02194	0.00091	--	--
TOTAL	39	0.02884			

TABLE III-21

ANALYSIS OF VARIANCE SUMMARY TABLE

REACTION TIME: INTROVERT EXPERIMENTAL GROUP

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P
Subject Sex (S)	1	0.00019	0.00019	0.02	(N.S.)
Ss within S	8	0.09162	0.01145	--	--
Periods (P)	3	0.02078	0.00693	10.44	<.005
S x P	3	0.00535	0.00178	2.69	(N.S.)
P x Ss within S	24	0.01594	0.00066	--	--
TOTAL	39	0.13388			

The principal analysis of variance (Table III-18) indicates that the levels of extraversion and the experimental periods main effect and the levels of extraversion by experimental periods interaction were statistically significant. Using Scheffé's test a systematic comparison of the subjects' mean reaction time for the three levels of extraversion and for the experimental periods was made. The results of these comparisons are given in Table III-22 and Table III-23.

TABLE III-22

SUMMARY TABLE SCHEFFE'S TEST

MEAN REACTION TIME BETWEEN LEVELS OF EXTRAVERSION

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
E vs. C	275.65	1.26	(N.S.)
E vs. I	2227.81	10.22	<.005
C vs. I	936.17	4.30	<.05
Average C + I vs. E	1356.92	6.23	<.025
Average E + C vs. I	2017.43	9.26	<.005
Average E + I vs. C	65.28	0.30	(N.S.)

TABLE III-23

SUMMARY TABLE SCHEFFE'S TEST

REACTION TIME: EXPERIMENTAL PERIODS FOR ALL SUBJECTS

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
1 vs. 2	31.66	0.93	(N.S.)
1 vs. 3	41.20	1.21	(N.S.)
1 vs. 4	407.51	11.98	<.005
2 vs. 3	0.63	0.02	(N.S.)
2 vs. 4	212.00	6.23	<.005
3 vs. 4	189.57	5.57	<.005
Average of 1 + 2 vs. 4	402.46	11.83	<.005
Average of 1 + 3 vs. 4	384.32	11.30	<.005
Average of 2 + 3 vs. 4	267.51	7.86	<.005
Average of 1 + 2 + 3 vs. 4	392.30	11.53	<.005
Average of 1 + 2 + 4 vs. 3	7.17	0.21	(N.S.)
Average of 1 + 3 + 4 vs. 2	15.76	0.46	(N.S.)
Average of 2 + 3 + 4 vs. 1	173.15	5.09	<.005

The analyses of variance on the reaction time data matrices obtained from each of the experimental groups (Tables III-19, III-20 and III-21) yielded statistically significant results for the extravert and introvert groups only. In the extravert group the experimental period main effect was significant at the 0.5% level. In the introvert group the experimental period main effect is also significant. Using

Scheffé's test the mean reaction time scores for each experimental period were compared in both the extravert and the introvert groups. The results of this procedure for the extravert group are given in Table III-24 and in Table III-25 for the introvert group.

TABLE III-24

SUMMARY TABLE SCHEFFE'S TEST

MEAN REACTION TIME DURING EXPERIMENTAL PERIODS - EXTRAVERT GROUP

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
1 vs. 2	16.43	0.30	(N.S.)
1 vs. 3	31.80	0.58	(N.S.)
1 vs. 4	411.51	7.52	<.005
2 vs. 3	2.51	0.05	(N.S.)
2 vs. 4	263.47	4.8	<.025
3 vs. 4	214.51	3.92	<.025
Average of 1 + 2 vs. 4	444.50	8.13	<.005
Average of 1 + 2 vs. 3	17.40	0.32	(N.S.)
Average of 1 + 3 vs. 4	406.74	7.43	<.005
Average of 2 + 3 vs. 4	317.81	5.81	<.005
Average of 1 + 2 + 3 vs. 4	436.28	7.98	<.005
Average of 1 + 2 + 4 vs. 3	9.18	0.17	(N.S.)
Average of 1 + 3 + 4 vs. 2	31.57	0.58	(N.S.)
Average of 2 + 3 + 4 vs. 1	149.79	2.74	(N.S.)

TABLE III-25

SUMMARY TABLE SCHEFFE'S TEST

MEAN REACTION TIME DURING EXPERIMENTAL PERIODS -

INTROVERT GROUP

COMPARISON	MEAN SQUARE DIFFERENCE	F	P
1 vs. 2	10.58	0.53	(N.S.)
1 vs. 3	29.52	1.48	(N.S.)
1 vs. 4	190.04	9.54	<.005
2 vs. 3	4.75	0.24	(N.S.)
2 vs. 4	110.92	5.57	<.005
3 vs. 4	69.75	3.50	<.05
Average of 1 + 2 vs. 4	197.11	9.89	<.005
Average of 1 + 2 vs. 3	19.23	0.97	(N.S.)
Average of 1 + 3 vs. 4	163.35	8.20	<.005
Average of 2 + 3 vs. 4	118.86	5.97	<.005
Average of 1 + 2 + 3 vs. 4	117.88	8.93	<.005
Average of 1 + 2 + 4 vs. 3	0.09	0.004	(N.S.)
Average of 1 + 3 + 4 vs. 2	14.91	0.75	(N.S.)
Average of 2 + 3 + 4 vs. 1	84.17	4.22	<.025

Our analysis of the subject's reaction times has so far made use of a mean value for the reaction time obtained by averaging the reaction time into a mean value for each experimental period. This

averaging process stabilizes the data variance and so tends to obscure subtle relationship in the data by causing the data analysis to become very conservative. To reduce this bias independent comparisons were made on the frequency distributions of reaction times for each experimental group during each experimental period. The frequency histograms for each experimental group during each experimental period show considerable deviation from the Gauss-Laplace or Normal Distribution; therefore it was deemed inadvisable to test the experimental hypotheses using statistical tests which make assumptions concerning the form of the data distribution.

The Kolmogorov-Smirnov two sample test (Kolmogorov, 1941; Smirnov, 1948) has been procedurized and reviewed by Siegel (1956) and by Bradley (1968). Briefly, it is a two sample test of whether two independent samples have been drawn from the same population or from populations with the same distributions. The two-tailed Kolmogorov-Smirnov test is sensitive to differences in the central tendency (location function) and dispersion (density function) of the population from which the two samples were drawn. The one-tailed Kolomogorov-Smirnov test is used to decide whether or not the values of the population from which one of the samples was obtained is stochastically larger than the values of the population from which the other sample was drawn (Siegel, 1956).

Using the Kolmogorov-Smirnov two sample test the cumulative frequency distributions for each of the experimental groups during each of the experimental periods were compared. Because of the large sample size, the Maximum Difference test statistic obtained from the Kolmogorov-Smirnov procedure was converted to Chi-square using the conversion procedure outlined by Goodman (1954). The results of the comparisons within groups are given in Table III-26. The results of the between group comparisons are given in Table III-27.

TABLE III-26

KOLMOGOROV-SMIRNOV TWO SAMPLE TEST

WITHIN GROUPS COMPARISON

ONE-TAILED TEST

COMPARISON	MAXIMUM DIFFERENCE	CHI* SQUARED	P	STOCHASTIC DECISION
E3, E4	- 0.1477	23.90	<.001	E4>E3
E4, E2	- 0.1761	33.80	<.001	E4>E2
E1, E4	- 0.2078	46.49	<.001	E4>E1
E2, E3	- 0.0448	2.13	(N.S.)	(E3>E2)
E1, E3	- 0.0768	6.16	<.05	E3>E1
E1, E2	- 0.0547	3.12	(N.S.)	(E2>E1)
C3, C4	+ 0.0436	2.11	(N.S.)	(C3>C4)
C2, C4	+ 0.0477	2.55	(N.S.)	(C2>C4)
C1, C4	- 0.0419	1.96	(N.S.)	(C4>C1)
C2, C3	+ 0.0232	0.60	(N.S.)	(C2>C3)
C1, C3	- 0.0490	2.65	(N.S.)	(C3>C1
C1, C2	- 0.0574	3.67	(N.S.)	(C2>C1)
I3, I4	- 0.1893	42.29	<.001	I4>I3
I2, I4	- 0.2542	76.27	<.001	I4>I2
I1, I4	- 0.2418	68.33	<.001	I4>I1
I2, I3	- 0.0668	5.26	(N.S.)	(I3>I2)
I1, I3	- 0.0697	5.67	(N.S.)	(I3>I1)
I1, I2	+ 0.0385	1.73	(N.S.)	(I2>I1)

* Chi-Square Approximation, DF=2

TABLE III-27

KOLMOGOROV-SMIRNOV TWO SAMPLE TEST

BETWEEN GROUPS COMPARISON

ONE-TAILED TEST

COMPARISON	MAXIMUM DIFFERENCE	CHI* SQUARED	P	STOCHASTIC DECISION
E1, C1	- 0.1852	36.58	<.001	C1>E1
E1, I1	- 0.3137	107.15	<.001	I1>E1
C1, I1	- 0.1464	24.27	<.001	I1>C1
E2, C2	- 0.1881	38.34	<.001	C2>E2
E2, I2	- 0.2889	92.84	<.001	I2>E2
C2, I2	- 0.1117	14.34	<.001	I2>C2
E3, C3	- 0.1652	29.51	<.001	C3>E3
E3, I3	- 0.2909	94.64	<.001	I3>E3
C3, I3	- 0.1620	29.83	<.001	I3>C3
E4, C4	+ 0.0957	10.29	<.01	E4>C4
E4, I4	- 0.3003	104.09	<.001	I4>E4
C4, I4	- 0.3308	125.55	<.001	I4>C4

*Chi-Square Approximation, DF=2

CHAPTER IV

DISCUSSION OF RESULTS

HYPOTHESIS 1:

Performance Decrement:

An analysis of variance on the missed response data for all subjects (Table III-2) yielded a significant level of extraversion main effect, a significant experimental periods main effect and a significant levels of extraversion by experimental period interaction effect. An analysis of this data by Scheffé's method (Table III-6) demonstrated that the extravert group made a significantly larger number of missed responses than did the introvert group. In an analysis of variance performed on the extravert subject data (Table III-3) only the experimental period main effect reached significance. Scheffé's test on this data (Table III-8) demonstrated that the average of experimental periods one, two and three was significantly different from experimental period four, the period following the programmed rest period. These results lend support to Eysenck's findings which suggest that performance decrement gradually increases during massed practice and shows a sharp drop following a rest period. The results also strongly support Eysenck's findings that performance decrement is greatest in the extravert group.

Using subject reaction time as a measure of performance, we find that there is very little difference in subject reaction time (Table III-17) summed over subjects and periods within each experimental group. An analysis of variance was performed on this data (Table III-18). The results showed that the levels of extraversion main effect, the experimental periods main effect, and the levels of extraversion by experimental periods main effect were statistically significant. Comparisons between the levels of extraversion using Scheffé's procedure

show that the extravert group is significantly different from the introvert group. The interpretation of this finding is that the extravert group has significantly greater reaction times than the introvert group.

However, analysis of the data using the Kolmogorov-Smirnov two sample test produces stochastic decisions opposite to those obtained from the analysis of variance and Scheffé's test. From Table III-27 the following ordering of the data emerges for each group during each experimental period:

Period 1: I>C>E
Period 2: I>C>E
Period 3: I>C>E
Period 4: I>E>C

This seeming inconsistency is readily understood when one considers the pattern of performance decrement in the various groups. In the extravert group performance decrement manifests itself by an increase in reaction time and also by an increase in performance variability. On the other hand, performance decrement in the control and introvert group is generally a simple increase in reaction time without a great deal of increase in performance variability. Therefore, in terms of the cumulative frequency distribution upon which the Kolmogorov-Smirnov test is based, the control and introvert groups have more "compact" performance distributions than the extraverts. Hence, the Kolmogorov-Smirnov test quite correctly renders its stochastic decisions.

HYPOTHESIS 2:

Reminiscence effects:

Reminiscence, the post-rest upswing in performance following a programmed rest pause, was evaluated by two measures in this study: reaction time and missed responses. From Figure III-1 it can be seen that the number of missed responses demonstrates a sharp decline in the extravert group following the rest period between experimental periods three and four. The summary table of Scheffé's test given in Table III-7 demonstrates that experimental periods three and four were not significantly different averaged over all subjects, but that the average numbers of missed responses in periods one, two and three was significantly different from the number of missed responses in period four. Breaking down this comparison into components for each of the three experimental groups, we find that there were no significant differences between the four experimental periods in the introvert and control groups, and in the extravert group that the number of missed responses in period three was not significantly different from the number of missed responses in period four. However, the average number of missed responses made by the extravert group was significantly smaller from the number of responses in experimental period four.

These results lend partial support to Eysenck's theoretical position regarding higher reminiscence in extraverts than in introverts.

This difference becomes even more apparent when the subject reaction times are examined. Table III-23 gives the results of comparisons by Scheffé's method of the mean subject reaction time for all

subjects in each experimental period. The differences between the average reaction time in periods one, two and three are significantly different from the mean reaction time in period four. The mean subject reaction time for period three is significantly different from the value observed in period four. When the mean reaction times during experimental periods are compared for the introvert and extravert groups (Table III-24), it is found that there is a significant difference between experimental periods three and four, and also between the average of experimental periods one, two and three and experimental period four. The results of a comparison between the extravert and the introvert groups for the fourth experimental period using the Kolmogorov-Smirnov two sample test indicates that the mean reaction time of the introvert group was significantly longer than mean reaction time of the extravert group. In summary, the results clearly demonstrate the presence of a reminiscence effect, and in accord with Eysenck's theoretical positions, the reminiscence effect is larger in the extravert group than in the introvert group.

HYPOTHESIS 3:

Subject Compensation for Performance Decrement:

From Table III-9 we can see that the mean number of invalid responses in the extravert group was more than ten times the mean number of responses in the introvert group and three times greater than the mean number of invalid responses for the control group. The analysis of variance summary table for all subjects (Table III-10) indicates that

the levels of extraversion main effect, the experimental periods main effect, and the extraversion by experimental periods interaction were highly significant. When this data is analyzed for each experimental group (Tables III-11, 12 and 13), it is found that only the results from the extravert group reach significance. In the introvert group, only the experimental periods main effect is significant.

Comparisons using Scheffé's method (Table III-14) were performed and the results of these comparisons were that the extravert group differed significantly from both the control and the introvert group. The interpretation of these comparisons is that the extravert group made a significantly greater number of invalid responses than the introvert or control groups. There were no significant differences between the introvert and the control group in the number of invalid responses made by each group.

Comparisons of the production of invalid responses made by all subjects for each experimental period (Table III-15) indicated that experimental periods one and two were significantly different from experimental period three, and that experimental period three was different from experimental period four. Further, the average of experimental periods one, two and three was significantly different from experimental period four. The interpretation of these results is that the number of invalid responses increased significantly in the first three experimental periods and that there was a significant decrease in the number of invalid responses in experimental period four following the rest period.

From Tables III-11, 12 and 13 it is apparent that only the

extravert group periods effect is highly significant. Comparing the number of invalid responses made in each experimental period by extravert subjects (Table III-16) we find that experimental period one is significantly different from experimental period three, and that period three is significantly different from period four. In addition, the average of periods one, two and three is significantly different from experimental period four. These results suggest that in the extravert group there is a significant increase in invalid responses during the first three periods and that there is a significant decrease in invalid responses in experimental period four.

In summary, the results obtained from the invalid response measure suggest that the extravert group makes significantly more invalid responses than the control and introvert group. There is no evidence to suggest that the introvert and control groups differed in the production of invalid responses.

The pattern of invalid responses suggests that the extravert subjects do attempt to compensate for performance decrement. That is, as performance declines the number of invalid responses increases, and when the post-rest upswing in performance following the programmed rest pause occurs, the number of invalid responses shows a sharp decrease, perhaps because as performance increases the subject is under less pressure to produce compensatory behavior. There is no evidence to suggest that similar patterns exist in the introvert or control groups.

HYPOTHESIS 4:

The Intermediate Performance Position of the Control Group:

The general prediction that the performance of the control group should fall medially between the performance of the introvert group and the performance of the extravert group has not received clear support.

When the groups are compared on the basis of missed responses (Table III-6), there is no significant difference between the extravert group and the control group. However, there is a significant difference between the extravert group and the introvert group and between the control group and the introvert group.

If invalid responses are used as the measure for group comparison measures, the opposite effect is found (Table III-14). Using this measure the extravert group is significantly different from the control group and the extravert group is also significantly different from the introvert group; yet, the control group is not significantly different from the introvert group.

Using mean reaction time as the comparison measure (Table III-22), we find that the pattern of group differences is similar to that obtained when missed responses are used as the comparison measure. That is, the extravert group is significantly different from the introvert group and the control group is significantly different from the introvert group; but, the extravert group is not significantly different from the control group.

In summary, it would seem that the placement of the performance of the control group is somewhere between the bounds set down by the

extravert and introvert groups. However, this position would also seem to be dependent on the performance measure being used and so no general statement concerning the verification of the experimental hypothesis can be made.

SUMMARY OF RESULTS

In general, the results of this experiment support the pattern of performance decrement in extraverts during continuous performance postulated by Eysenck's theory. However, there is no support for this theory with regard to the control and to the introvert groups. While the extravert group's performance is significantly different from the performance of the control and the introvert groups, there is little evidence of difference between the control and the introvert groups. This lack of difference tends to suggest that Eysenck's placement of the three groups along the E-I personality dimension does not adequately distinguish between controls and introverts. One would expect that if the control group really occupied the central area of a polar dimension, the performance of this group should be intermediate with respect to the performance of the two polar groups.

The experimental results also strongly support Eysenck's findings regarding compensatory behavior during periods of performance decrement in the extravert group.

No evidence was found in this study to support an interaction between subject's sex and extraversion reported by Brebner (McPherson, 1965).

The experimental results strongly support the predictions concerning reminiscence made by Eysenck's theory. It was found that reminiscence was greatest in the extravert group and least in the introvert group.

An additional finding of this study is that there is some evidence to support the concept of the 'measure specific nature' of

performance decrement. From the experimental findings it is quite apparent that the statistical outcome of the experimental procedure depends largely on the sample statistic that is used in the data analysis. For example, the measure frequently used by Eysenck and his co-workers is performance variability using a measure of variance as the statistical measure. When measures of variance are used, the results quite closely fit Eysenck's theory which is empirically derived from similar measures. On the other hand, if a measure of central tendency is used, a pattern of performance decrement seemingly quite different from Eysenck's findings will result.

SUGGESTIONS FOR FUTURE RESEARCH

This study was an exploratory study and a post-hoc analysis of its design and execution suggests several improvements that could be made.

The first recommendation is that an improved measure of extraversion be found. The experimental findings tend to suggest that the multi-factor nature of Eysenck's E-I dimension is so broad that it is difficult to make accurate predictions from the theory because of the interaction of the E-I dimension's component factors. Experimenters using the EPI should be aware that quite recent research on the nature of the EPI factors by Howarth et. al. (1970) suggests that there are at least two major factors in the EPI Extraversion-Introversion dimension: "Social Extraversion" and "Impulsivity". Therefore, at

the very least, these factors should be determined and, in future research, the experimental results should be analyzed using multivariate statistical techniques.

A second recommendation is that future research should center on the compensatory behavior of the extravert group during periods of task performance decrement. It would seem quite inconsistent with Eysenck's theory that reactive and conditioned inhibition processes that cause task performance decrement should not also interfere with compensatory behavior. Yet, the experimental findings of this study clearly demonstrate that compensatory activities increase rapidly, even during periods of maximum task performance decrement. This compensatory behavior also seems to demonstrate a 'reverse' reminiscence effect; that is, following a programmed rest period compensatory behavior occurs at a lower rate than before the rest period. The only suggested explanation consonant with Eysenck's theory is that the drive maintaining the compensatory behavior is large enough to overcome the effects of inhibition; and in some manner, this drive increases in response to increasing performance decrement. The exact mechanism underlying this effect needs considerable empirical and theoretical clarification.

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APPENDICES

APPENDIX A

APPENDIX A

MATSCAN Computer Program

The MATSCAN computer program (Figure A-1) is an APL source language program for the construction of 2 x 2 (four element) square matrices for use as stimuli in vigilance experiments.

The elements of the matrix may be any permitted alphanumeric character contained in the APL source language. The matrix is constructed by drawing J items from the pool of items contained in the literal vector F. The probability of drawing any individual item is controlled by adjusting the frequency of occurrence of the item in the item pool, F. The spacing of the matrix is adjusted by changing the value of N. The original alpha operator contained in the DOS/360 version of APL is not available in the current OS/360 release of APL and so has been replaced by the program ALPHA. The program is recursive and the number of matrices generated is controlled by the value of U.

A sample of MATSCAN output is given in Figure A-2. The "critical" stimuli in this sample are denoted by arrows to the right of the critical matrix. In practice, these matrices are individually photographed and the resulting transparency is used as the actual stimulus.

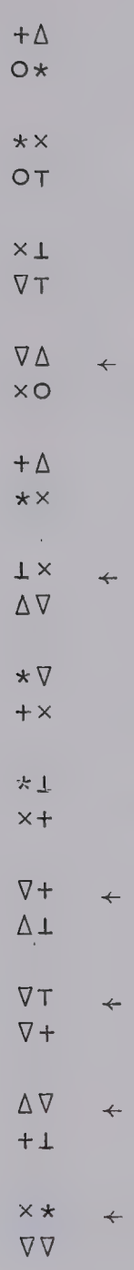
FIGURE A-1

```
      ∇MATSCAN[□]∇

     ∇ MATSCAN
[1]    I←1
[2]    D←F[J?ρF]
[3]    D←(2,N,2)ρD
[4]    D←(10 ALPHA 2)\D
[5]    D←(2,10×N)ρ,D
[6]    D
[7]    →(U≥I←I+1)/2
     ∇

      ∇ALPHA[□]∇

     ∇ R←N ALPHA J;I;JV
[1]    JV←,J
[2]    R←⍳I←0
[3]    R←R,N↑(N⌊JV[I←I+1])ρ1
[4]    →3×⍳I<ρJV
[5]    R←((ρJ),N)ρR
     ∇
```

THE APL SOURCE LANGUAGE PROGRAMS

MATSCAN AND ALPHA

FIGURE A-2



SAMPLE OUTPUT FROM THE MATSCAN PROGRAM

In this figure the critical stimuli are denoted with arrows.

APPENDIX B

APPENDIX B

EYSENCK PERSONALITY INVENTORY

by

H. J. Eysenck and Sybil B. G. Eysenck

Personality Questionnaire

Instructions:

Here are some questions regarding the way you behave, feel and act. After each question is a space for answering "YES" or "NO".

Try to decide whether "YES" or "NO" represents your usual way of acting or feeling. Then put a cross in the circle under the column headed "YES" or "NO". Work quickly, and don't spend too much time over any question; we want your first reaction, not a long-drawn out thought process. The whole questionnaire shouldn't take more than a few minutes. Be sure not to omit any questions.

Now turn the page over and go ahead. Work quickly, and remember to answer every question. There are no right or wrong answers, and this isn't a test of intelligence or ability, but simply a measure of the way you behave.

FORM A

1968

		Yes	No
1.	Do you often long for excitement?	Y	N
2.	Do you often need understanding friends to cheer you up?	Y	N
3.	Are you usually carefree?	Y	N
4.	Do you find it very hard to take no for an answer?	Y	N
5.	Do you stop and think things over before doing anything?	Y	N
6.	If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so?	Y	N
7.	Does your mood often go up and down?	Y	N
8.	Do you generally do and say things quickly without stopping to think?	Y	N
9.	Do you ever feel "just miserable" for no good reason?	Y	N
10.	Would you do almost anything for a dare?	Y	N
11.	Do you suddenly feel shy when you want to talk to an attractive stranger?	Y	N
12.	Once in a while do you lose your temper and get angry?	Y	N
13.	Do you often do things on the spur of the moment?	Y	N
14.	Do you often worry about things you should not have done or said?	Y	N
15.	Generally, do you prefer reading to meeting people?	Y	N
16.	Are your feelings rather easily hurt?	Y	N
17.	Do you like going out a lot?	Y	N
18.	Do you occasionally have thoughts and ideas that you would not like other people to know about?	Y	N
19.	Are you sometimes bubbling over with energy and sometimes very sluggish?	Y	N
20.	Do you prefer to have few but special friends?	Y	N
21.	Do you daydream a lot?	Y	N
22.	When people shout at you, do you shout back?	Y	N

23.	Are you often troubled about feelings of guilt?	Y	N
24.	Are all your habits good and desirable ones?	Y	N
25.	Can you usually let yourself go and enjoy yourself a lot at a gay party?	Y	N
26.	Would you call yourself tense or "highly-strung"?	Y	N
27.	Do other people think of you as being very lively?	Y	N
28.	After you have done something important, do you often come away feeling you could have done better?	Y	N
29.	Are you mostly quiet when you are with other people?	Y	N
30.	Do you sometimes gossip?	Y	N
31.	Do ideas run through your head so that you cannot sleep?	Y	N
32.	If there is something you want to know about, would you rather look it up in a book than talk to someone about it?	Y	N
33.	Do you get palpitations or thumping in your heart?	Y	N
34.	Do you like the kind of work that you need to pay close attention to?	Y	N
35.	Do you get attacks of shaking or trembling?	Y	N
36.	Would you always declare everything at the customs, even if you knew that you could never be found out?	Y	N
37.	Do you hate being with a crowd who play jokes on one another?	Y	N
38.	Are you an irritable person?	Y	N
39.	Do you like doing things in which you have to act quickly?	Y	N
40.	Do you worry about awful things that might happen?	Y	N
41.	Are you slow and unhurried in the way you move?	Y	N
42.	Have you ever been late for an appointment or work?	Y	N
43.	Do you have many nightmares?	Y	N
44.	Do you like talking to people so much that you never miss a chance of talking to a stranger?	Y	N
45.	Are you troubled by aches and pains?	Y	N

46.	Would you be very unhappy if you could not see lots of people most of the time?	Y	N
47.	Would you call yourself a nervous person?	Y	N
48.	Of all the people you know, are there some whom you definitely do not like?	Y	N
49.	Would you say that you were fairly self-confident?	Y	N
50.	Are you easily hurt when people find fault with you or your work?	Y	N
51.	Do you find it hard to really enjoy yourself at a lively party?	Y	N
52.	Are you troubled with feelings of inferiority?	Y	N
53.	Can you easily get some life into a rather dull party?	Y	N
54.	Do you sometimes talk about things you know nothing about?	Y	N
55.	Do you worry about your health?	Y	N
56.	Do you like playing pranks on others?	Y	N
57.	Do you suffer from sleeplessness?	Y	N

PLEASE CHECK TO SEE THAT YOU HAVE ANSWERED ALL THE QUESTIONS